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The purpose of this instructional unit is to convey an understanding of the part played by effective problem definition and hypothesis statement in the solution of scientific problems. The major concepts of the unit are process rather than content oriented. Problems, hypotheses, variables, constants and controls represent the principal concepts emphasized in the unit. The unit is organized into four parts: Recognizing Problems, Stating Problems Effectively, Formulating Hypotheses, and Testing Hypotheses. The teaching materials consist of an informational narrative, a set of illustrative slides, and worksheets for the students. A multiple choice post-test is provided as a means of evaluating student attainment of eight behavioral objectives. This work was prepared under ESEA Title III contract. (BC)

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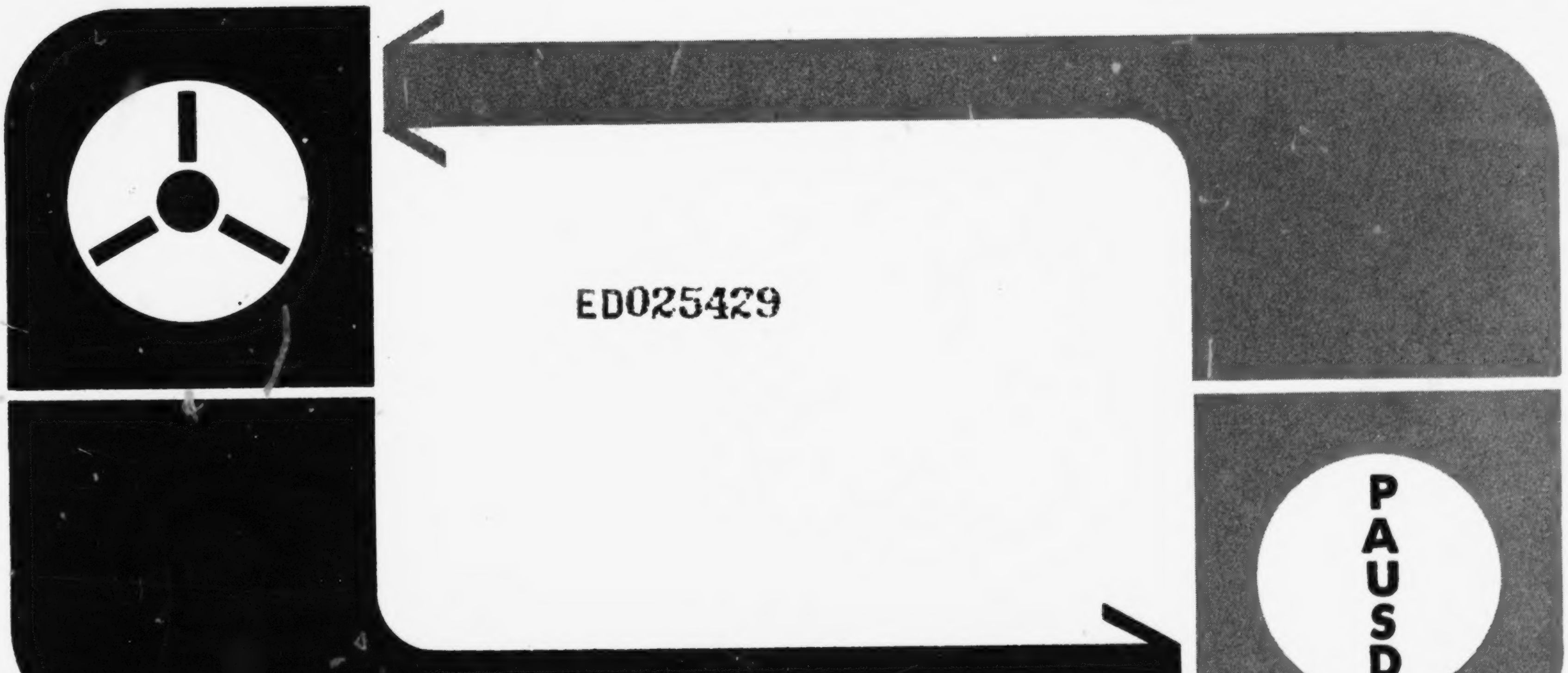
CUBBERLEY/LOCKHEED SCIENCE PROJECT

FINAL REPORT

VOLUME II – EXPERIMENTAL INSTRUCTIONAL MATERIALS



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AN INSTRUCTIONAL PACKAGE
FOR A UNIT ON
SCIENTIFIC INQUIRY

Prepared by the Staff
of the
CUBBERLEY LOCKHEED SCIENCE PROJECT
Cubberley Senior High School
of the
Palo Alto Unified School District
February 1968

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Inquiry Unit

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Inquiry Unit Introduction

The purpose of this unit is to convey an understanding of the part played by effective problem definition and hypothesis statement in the solution of scientific problems. It also initiates instruction through which the student learns to prepare effective problem statements and follow them with hypothesis statements that can be used to solve the problems.

The content for the Unit is a local problem that has both scientific and social-recreational interest. Clear Lake, easily reached from Palo Alto, contains extensive algae growth. By contrast, Lake Tahoe is relatively free of algae. The general scientific problem is why this difference exists.

The major concepts for the unit are process rather than content oriented. Problems, hypotheses, variables, constants, and controls represent the principal concepts emphasized in the Unit.

Inquiry Unit Teacher Rationale

The unit is organized into four parts: I. Recognizing Problems, II. Stating Problems Effectively, III. Formulating Hypotheses, and IV. Testing Hypotheses.

The unit is brief; the intent is to cover it in five typical class periods of instruction or less with one part of the Unit presented per period and a post test given in the fifth period.

The teaching materials are composed of an informational narrative, a set of illustrative slides that support the narrative, and worksheets for the students. These materials can be used in a lecture-discussion mode or if the narrative is put on audio tape, they can be used in an individualized mode where the student can exercise personal control over his progress through the unit.

Inquiry Unit Student Rationale

This unit is planned to allow you to learn to: recognize problems, identify the conditions that lead to problems, interpret data about problems, state problems in an effective way, identify the control measures to use in investigations, and write hypotheses in what is called the "If-and-then" form.

The unit uses a minimum amount of new science content material. It starts you on the learning of intellectual skills which you can use over and over again as you study science.

The unit is composed of an informational narrative, illustrative slides and a worksheet. The narrative and slides present information to you and the worksheet helps you to conduct a self test of how well you understand and whether you can apply your understanding.

Inquiry Unit Instructional Objectives

The student can, after a study of this package:

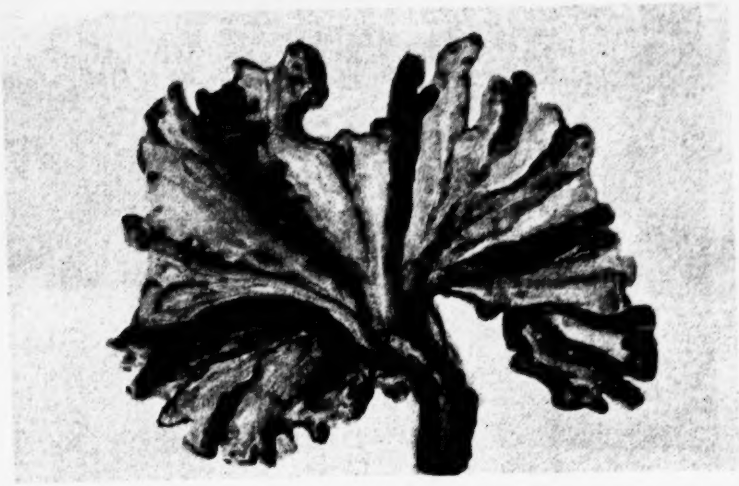
1. recognize problems suitable for a natural scientist to investigate,
2. distinguish between problems that are due to observed differences and those that are cause and effect relationships in origin,
3. interpret data about problems that are presented orally, through pictures or as real objects,
4. recognize and distinguish effectively stated, investigatable problems from ineffectively stated problems,
5. state, in writing, specific natural science problems so that they can be tested by investigation,
6. identify the significant variables and constants associated with given natural science problems,
7. identify and describe the control measures to use in investigating a specific problem,
8. state, in writing, three alternate forms of a hypothesis in the "If-and-then" format for a given problem presented to him in oral, visual or real object form.

NARRATIVE FOR LARGE GROUP, SMALL GROUP, OR TAPED PRESENTATION

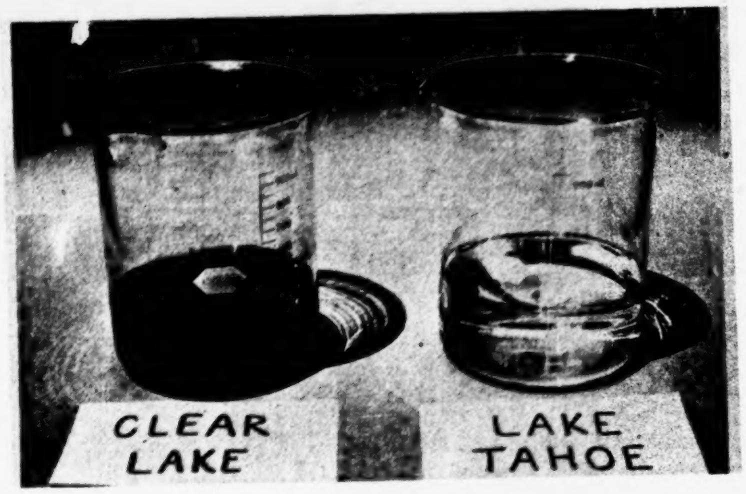
I. Recognizing Problems

Two Palo Alto families planned to spend a weekend water skiing together. The Harts suggested that they go to Clear Lake in Lake County, but the Beattys said they preferred Lake Tahoe. Lew Hart explained that they would have more time for skiing at Clear Lake since it was closer, but Bill Beatty said his family did not enjoy skiing there because of the water plants, called algae, that filled the water. [#1]*

GO TO QUESTION 1 ON THE WORKSHEET



Slide 1



Slide 2

The two families are faced with a problem. Should they take the time to travel to Lake Tahoe for better water skiing or should they settle for less ideal conditions at Clear Lake? A natural scientist sees a different problem. Why does Clear Lake have such an extensive growth of algae while Lake Tahoe does not [#2], or what makes the difference in algae growth?

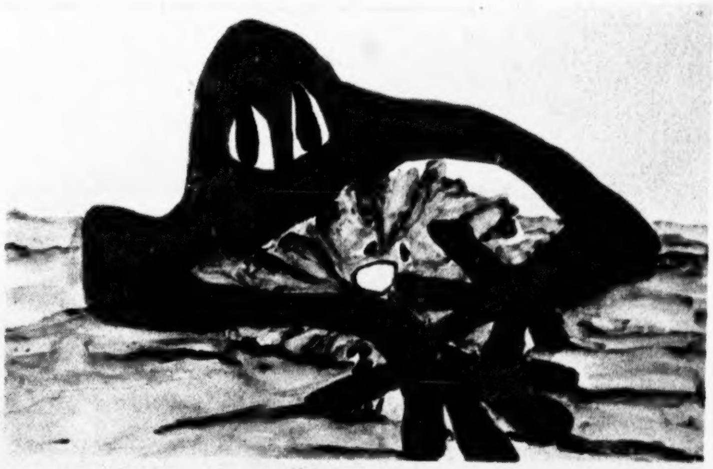
---

*Numbers refer to slides.

Note that the Beattys, during the past experiences with the two lakes, had observed this difference in relation to water skiing. The type of problem recognized depends upon the investigator's point of view. For example, a geologist might be curious about why there aren't more lakes near Palo Alto, and a social scientist might wonder why people value different aspects of the sport of water skiing. [#3]

A curiosity about differences is one of the major ways in which problems of significance to natural scientists arise. Sometimes this difference is observed all at once; at other times only one aspect is observed--like Clear Lake having algae, while the different aspect is recalled from memory of past experience--like Lake Tahoe not having algae when you last saw it. (OBSERVATION OF DIFFERENCES CAN LEAD TO PROBLEM FORMULATION.) But the Harts and Beattys still have the problem of where to go skiing.

Slide 3



Slide 4

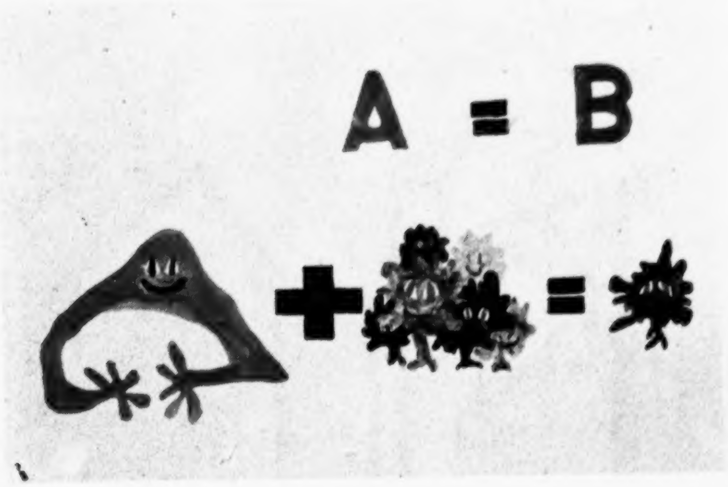
Bill Beatty suggested that the California State Park and Recreation Commission ought to control the growth of algae in Clear Lake. Bill knows that he was able to control algae growth in his swimming pool by adding copper sulfate to the water.[#4]

TURN TO QUESTION 2 ON THE WORKSHEET

What aspect of this situation suggests a problem for a natural scientist? (Remember, you are studying the nature of situations which result in problems, and observed differences is only one of the conditions which can result in problems.)

Here, there is no clearly observable difference to lead to a problem.

Bill is suggesting that copper sulfate changes or affects the growth of algae. From his past experience with his swimming pool, he is proposing that it is possible to change the conditions in Clear Lake so as to eliminate or reduce the growth of algae; by making this suggestion, Bill has used a problem solving technique frequently used by scientists. Scientists look for relationships between two aspects of a situation. One aspect, which we will call A, is followed by another, which we will call B. In this case, Bill Beatty is saying that copper sulfate added to extensive algae growth (A), results in or is followed by reduced growth of algae (B). [#5] We can then say that A always precedes B, and B always follows A.



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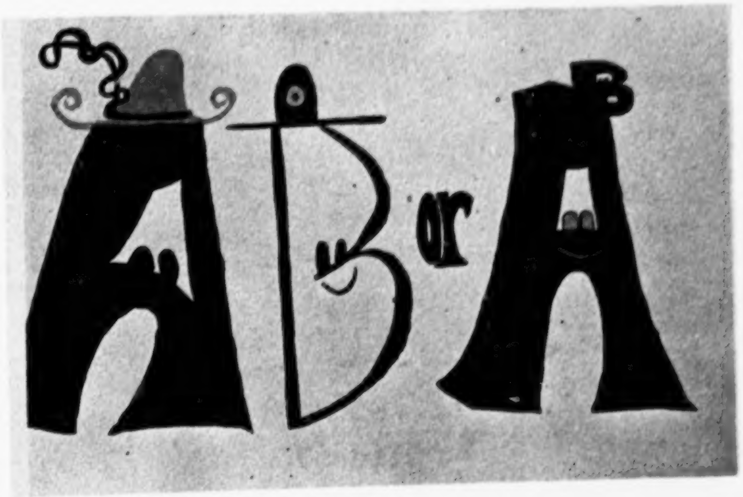


Slide 6

The situation where B always follows A is termed Cause and Effect. When we talk about A causing B, we do not put any restriction on the amount of time required for A to cause B. [#6] B may follow A immediately in time or B may follow A after an interval of time. The scientist is interested in finding the possible mechanisms that explain or establish a connection between A and B. THIS, THEN IS A SECOND CONDITION CHARACTERISTIC OF PROBLEM FORMULATION: THE IDENTIFICATION OF POTENTIAL RELATIONSHIPS BETWEEN ASPECTS OF A SITUATION.

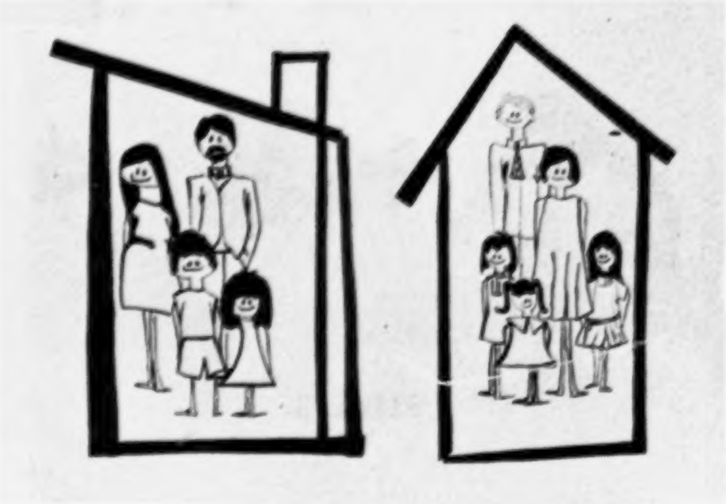
One example of this kind of a relationship is, "How does copper sulfate control the growth of algae?" Other examples are, "Why is prolonged exercise followed by aching muscles? why does the sun move across the sky each day? and why do some families have more red haired children than others?" [#7]

THERE ARE TWO CONDITIONS CHARACTERISTIC OF PROBLEM FORMULATION. THE FIRST IS THE OBSERVATION OF DIFFERENCES; THE SECOND IS THE OBSERVATION THAT ONE EVENT ALWAYS FOLLOWS ANOTHER EVENT. WHENEVER YOU ARE ASKED TO RECOGNIZE A PROBLEM, ALWAYS LOOK FOR (1) DIFFERENCES, OR (2) POTENTIAL CAUSE AND EFFECT RELATIONSHIPS, OR (3) BOTH DIFFERENCES AND CAUSE AND EFFECT RELATIONSHIPS.

We have suggested that scientists find problems in situations by observing a difference or by observing that B always follows A (that is, that A is a possible cause of B). To check your understanding, try to identify a scientific problem in each of the following situations: Differentiate those which arise from differences from those which contain a possible cause and effect situation (That is, A is followed by B).

TURN TO QUESTION 3 ON THE WORKSHEET

Slide 7



WORK SHEET TO ACCOMPANY TAPED PRESENTATION

(Or for Use with Group Presentations)

WORKSHEET INSTRUCTIONS

The purpose of this Worksheet is to provide you with questions which will help you to check your understanding of the material presented. These questions have been provided for your own benefit; they will not be graded. They will be of no help if you do not answer them, nor will it help if you look at the answers before you have attempted an answer. The questions follow the sequence of information presented on tape and slides.

To use the Worksheet, begin by covering the answers on the page. Then read the first question and answer it as accurately and as briefly as possible. Once you have answered the question, check your answer with the answer provided. If you have answered the question correctly, proceed to the next question. However, if you have made a mistake or cannot answer the question, ask the teacher for help. You may need to listen to the tape-slide presentation again. Continue through all of the questions of the Self-check. At the end of a Self-check section, you will return to the tape-slide presentation unless otherwise instructed. Below is an example question.

Question:

What does a biologist study?

a biologist studies life in all its forms.

ANSWER: (to be covered)

A biologist studies life in all of its forms.

I. Recognizing Problems

Question 1:

Description:

Two Palo Alto families planned to go water skiing together. The Harts suggest Clear Lake. The Beattys prefer Lake Tahoe. Lew Hart chooses Clear Lake because it's closer; Bill Beatty dislikes Clear Lake because of algae growth.

Question:

What aspects of this situation might be considered a problem by a natural scientist? (Webster defines problem as a question proposed for solution.)

ANSWER

Why does Clear Lake have such an extensive growth of algae while Lake Tahoe does not?

What makes the difference in algae growth?

STOP--RETURN TO NARRATIVE

Question 2:

Description:

One of the conditions which can result in the recognition of problems is the observation of differences. Bill Beatty has suggested that copper sulfate might be used to control algae growth in Clear Lake, since it does so in his pool.

2. Continued

Question:

The observation of differences is one way to recognize a problem. A second way to recognize a problem is suggested in Bill Beatty's proposal that by adding copper sulfate, algae growth can be reduced. What way is suggested in Bill's proposal?

ANSWER

There is no clearly observable difference to lead to a problem. Bill is proposing that it is possible to change the conditions in Clear Lake so as to eliminate the growth of algae. He is looking for the relationship between two aspects of a situation. He is looking for the effects of copper sulfate on algae growth.

STOP--RETURN TO NARRATIVE

Question 3: REVIEW OF PROBLEM RECOGNITION

To check your understanding of problem recognition, consider the scientific problem to be found in each of the following situations. You are to (A) describe the problem, and (B) identify whether the problem arises from Differences or from Cause and Effect Relationships, or Both. Write your answers underneath the statements.

EXAMPLE

Question:

Two kinds of algae grow in Clear Lake. One is green, filamentous, and narrow-leaved. The other is brown, composite, and broad-leaved. [#8]

A.

B.

ANSWER

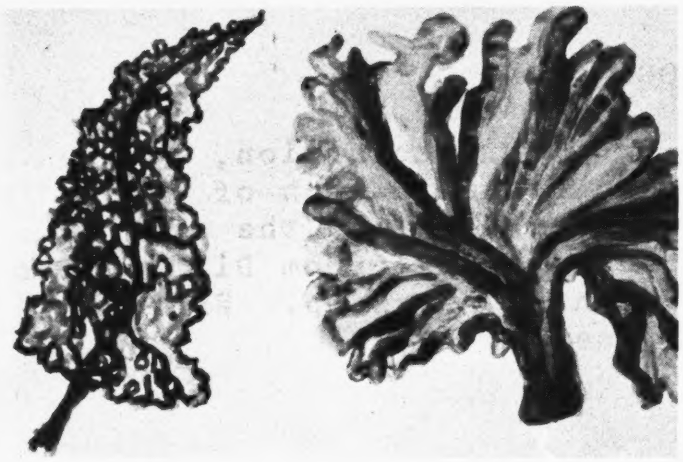
A. Why are there two kinds of algae, or why are two kinds of algae found in one lake?

B. Observed differences lead to a problem.

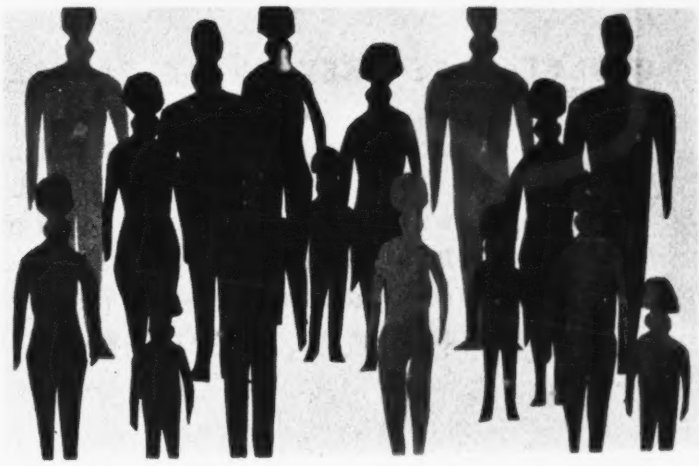
You are to answer the next eight questions, always with an (A) and (B) part. The numbers refer to slides in your projector, and you should turn to the appropriate slide as indicated.

A. WORD DESCRIPTIONS

1. In certain areas of the United States, an unusually large number of persons have suffered from a condition of the thyroid gland, called goiter, which results in an enlarged neck. [#9, 10]



Slide 8



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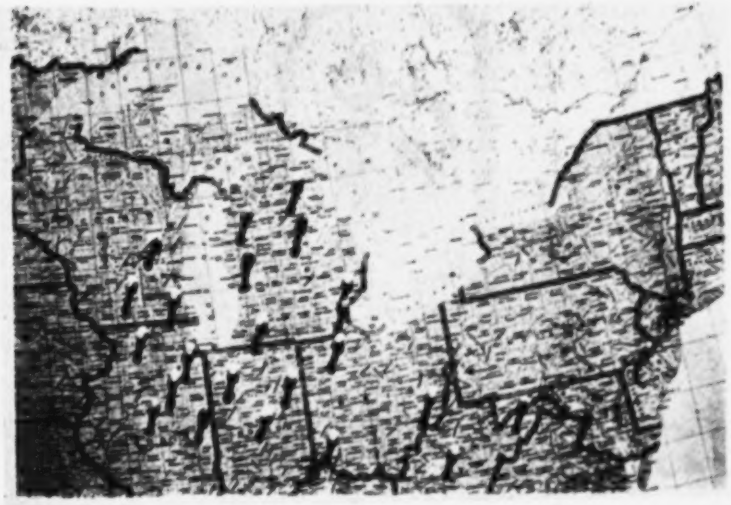


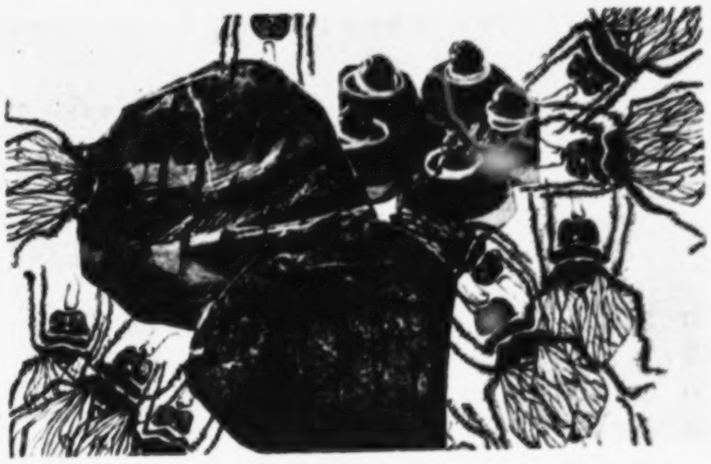
A.

B.

Slide 10

ANSWER
A. What aspect of these regions lead to goiter?
B. A (Aspect of region) leads to B (High incidence of goiter). Cause and effect.

2. Flies are always found on and around exposed pieces of meat. [#11]

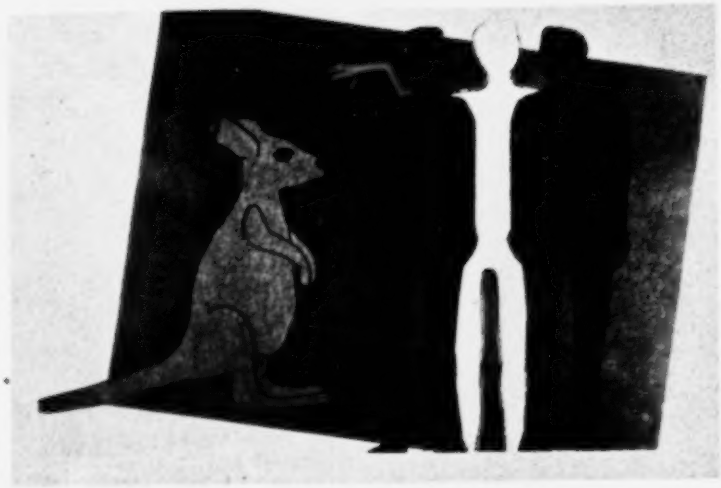


A.

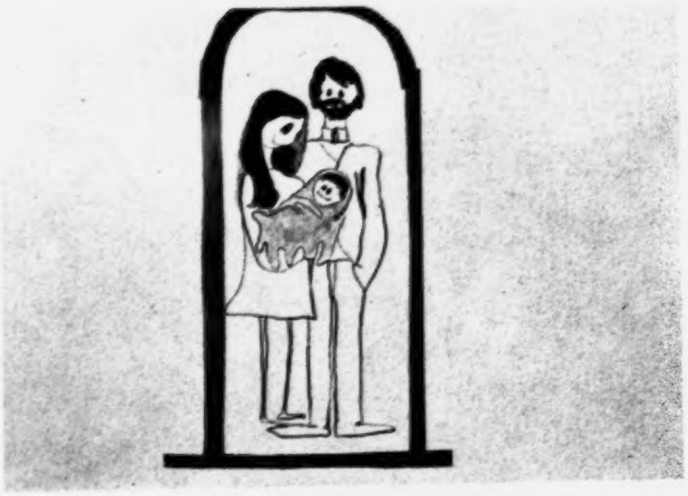
B.

Slide 11

ANSWER
A. What relationship exists between flies and meat?
B. Cause and Effect--A (meat) leads to B (presence of flies).



Slide 12



Slide 13

3. Some animals with four limbs only use two limbs for walking. [#12]

   A.

   B.

   ANSWER
   A. Why is there a difference in the use of limbs among animals?
   B. Observed differences lead to a problem.

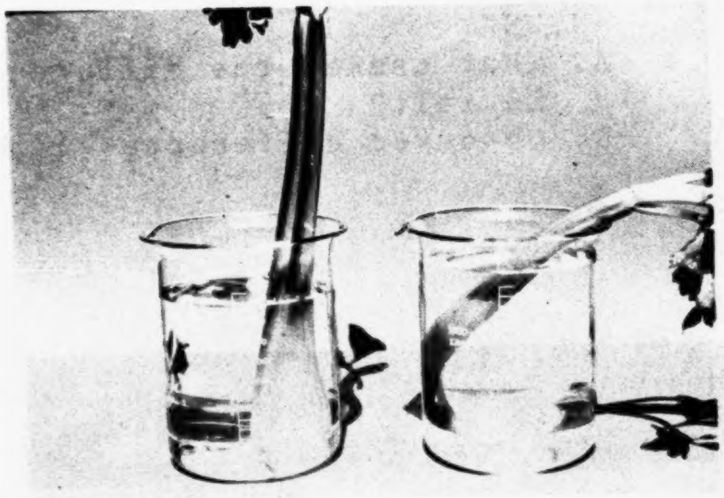
4. Parents with brown hair have a red haired baby. [#13]

   A.

   B.

   ANSWER
   A. Why is there a difference in hair color? What causes the difference of color in hair?
   B. Observed differences lead to a problem. Cause and Effect --what caused the difference in color?

Slide 14



Slide 15

5. A green, leafy plant and a cactus. [#14]

   A.

   B.

   ANSWER
   A. Why are the two plants different?
   B. Observed differences lead to a problem.

6. Your own thumb and your index finger.

   A.

   B.

   ANSWER
   A. Why are the two fingers different?
   B. Observed differences lead to a problem.

7. A stalk of celery in a 20% salt solution, and a stalk in a 5% salt solution. [#15]

   A.

   B.

ANSWER
A. What caused the difference? What causes celery to wilt in salt?
B. Observed differences lead to a problem. A results in B.

Slide 16

8. The plumage of a male bird and a female bird of the same species. [#16]

A.

B.

ANSWER
A. What causes male and female birds of the same species to have different plumage?
B. Observed differences lead to a problem. A results in B.

STOP--GO TO PART II

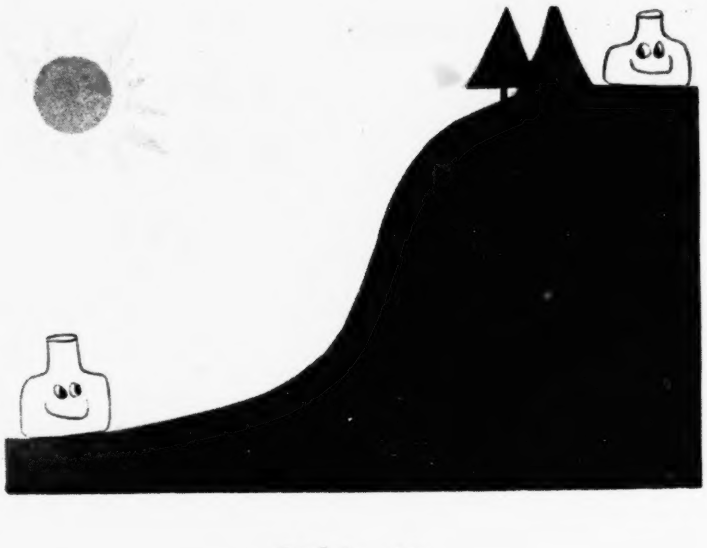
NARRATIVE FOR LARGE GROUP, SMALL GROUP,

OR TAPED PRESENTATION

II. Stating Problems Effectively

Let's go back to the Harts' and Beattys' problem of which lake to use for water skiing. Bill Beatty's son, John, decided that he wanted to find out why Clear Lake has so much algae. He asked his father what he thought caused all the algae in Clear Lake. Bill suggested that it might be the temperature of the water or the altitude of the lake that affected the algae and allowed it to grow. John decided that he would do an experiment to find what caused algae growth in the lakes. He decided to place a quart of Clear Lake water in each of two clear glass bottles along with some algae. He placed one bottle at sea level in Palo Alto and took the other to the altitude of Lake Tahoe. [#17] He found that recorded water temperatures at Clear Lake, Lake Tahoe and Palo Alto were about the same. John observed the bottles of water after one week for differences in amount of algae growth. He observed that the same quantity of algae was visible in both bottles. [#18]

TURN TO QUESTION 4 ON THE WORKSHEET



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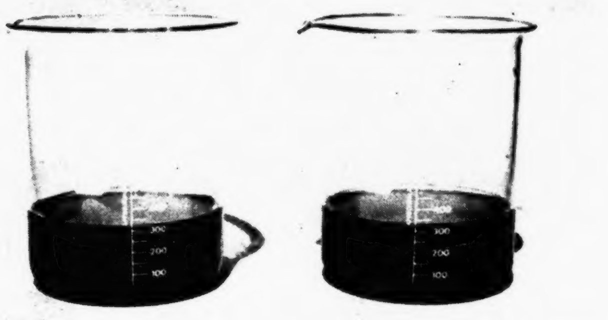


Slide 18

What possible cause is John testing in this experiment?

Does John's experiment show that a certain temperature is necessary for algae to grow?

Does his experiment show that water is necessary for algae to grow?

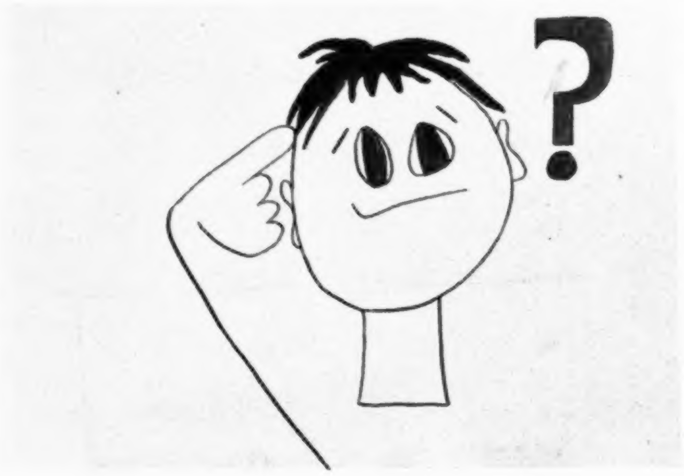
Does it show that algae is always present in water?

These questions are asked to get you to realize what John's experiment does not do. It does not provide information about the effects of temperature, the presence or absence of water, any more than it shows the effect of using clear glass bottles. To know what interpretation is possible from an experiment like John's, it is necessary to know what factor is clearly different in the surroundings of the two bottles.

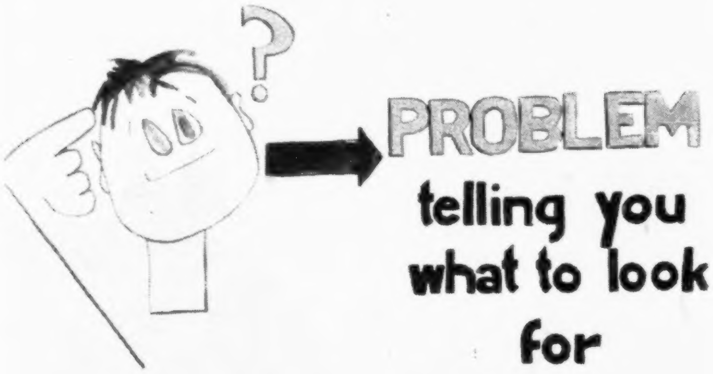
TURN TO QUESTION 5 ON THE WORKSHEET

What factor is clearly different in John's experiment?

Altitude is the factor that is different.



Slide 19



Slide 20

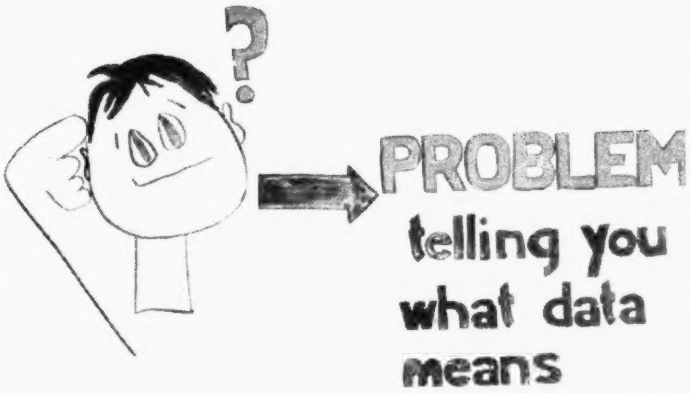
John Beatty started with a general curiosity and a very general problem about why Clear Lake has so much algae. [#19] The problem that he finally wanted to test was "What effect does altitude have on the growth of algae?"

General wonderments or curiosities are quite desirable, but in their very general form they cannot be investigated. Bill Beatty suggested several very specific possible causes for the algae growth. Temperature of the water was one of them. John concentrated on a test of another, that of altitude, as a possible cause. Both of these factors can become points of specific focus and study. A very specific problem can be stated around each factor. These statements, by their specific nature, help to indicate what information is needed to answer the problem. We can say that: AN EFFECTIVELY STATED PROBLEM INDICATES SPECIFICALLY WHAT INFORMATION OR DATA IS NEEDED. [#20]

Another way of judging whether a problem statement is effective is whether it begins with a "why" or"does". Most of the examples using "why" were ineffective, while those using the word "does" were effective problem statements.

John actually tested the problem: Does altitude affect the growth of algae?

GO TO QUESTION 6 ON THE WORKSHEET



Slide 21

Are there any possible answers or interpretations of the results that are suggested to you by this problem statement?

A general question such as "Why does Clear Lake have so much algae?" is not helpful as a problem statement. It does not suggest possible answers or interpretations to us. By contrast a specific question such as "Does altitude affect the growth of algae?" does help us. It suggests answers or how to interpret the results of an experimental test. We can say that: ANOTHER ASPECT OF AN EFFECTIVELY STATED PROBLEM IS THAT IT SUGGESTS POTENTIAL ANSWERS AND INTERPRETATIONS OF THOSE ANSWERS. [#21]

In summary: an effective problem statement helps us think about a problem situation. It specifically suggests what information we need to collect to answer the problem, and it suggests how we can interpret the information that we collect. An effective problem statement will often begin with the word does.

GO TO QUESTION 7 ON THE WORKSHEET

WORK SHEET TO ACCOMPANY TAPED PRESENTATION

(Or for Use with Groups of Students)

II. STATING PROBLEMS EFFECTIVELY

Question 4:

Description:

John decided to do an experiment on what caused algae growth in the two lakes. He placed a bottle of water containing algae at Palo Alto and at Lake Tahoe. After one week he observed the two bottles and found equal amounts of algae in both bottles.

Question A:

What possible cause of algae growth is John testing in this experiment?

ANSWER
The effect of altitude (Palo Alto versus Lake Tahoe altitude) on the growth of algae.

Question B:

Would John's experiment show that a certain water temperature is necessary for algae growth? Yes or No.

ANSWER
No, since there is no temperature variation.

Question C:

Would his experiment show that water is necessary for algae to grow? Yes or No.

ANSWER
No, since water is common to all tests.

STOP--RETURN TO NARRATIVE

Question 5:

Question:

What factor is clearly different; i.e. varies, in John's experiment?

ANSWER
Altitude is the factor that would be different--varies.

STOP--RETURN TO NARRATIVE

Question 6:

Question:

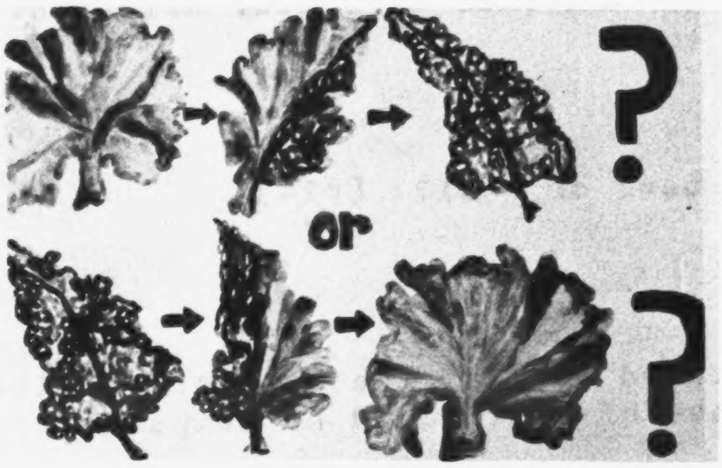
John actually tested the problem "What effect does altitude have on the growth of algae?" What possible answers or interpretations are suggested to you by this problem statement? What would you say if John found differences in algae growth? If he didn't find differences?

ANSWER
If John had found differences in algae growth, he could interpret these differences as being due to the effect of altitude. Since he found no difference in algae growth, he can say that altitude is not a cause of algae growth, and therefore, did not contribute to the differences found between Clear Lake and Lake Tahoe.

STOP--RETURN TO NARRATIVE

Question 7:

To review the ideas necessary to state a scientific problem, examine the following statements of problems. If it is specific enough to lead to an experiment, show what would be tested. If it is not specific enough, restate it to make it specific enough to lead to an experiment. Again, the numbers refer to slides found in your projector. Turn to the appropriate slide.



Slide 22

MORTON SALT

Slide 23

Question A:

Why are there two kinds of algae in Clear Lake? [#22]

ANSWER
Not specific enough, as no particular information is shown as being needed. Better statements might include:

A. Does green algae change into brown algae, or vice-versa, at a later time in its life cycle? (Consider green algae and time)

B. Do the brown and green algae always occur together in all lakes which have these algae? (Consider algae and all algae-filled lakes)

Many other specific statements are possible.

Question B:

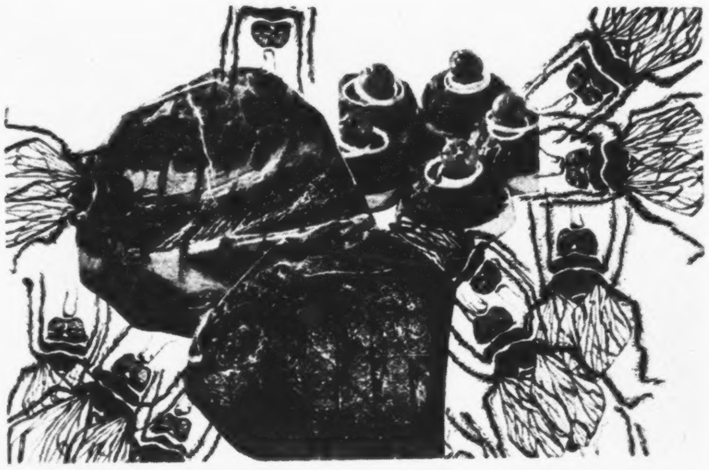
Does diet affect the formation of goiters? [#23]

ANSWER
This indicates that diets of those suffering from goiter could be compared to diets of those not suffering from goiter. Another alternative would be to create special diets for people, which lack a specific substance in each case, to see if the incidence of goiter differed.

Question C:

Do flies prefer to eat beef or veal? [#24]

ANSWER
This is specifically stated so that the numbers of flies on and near the two types of meat could be compared.



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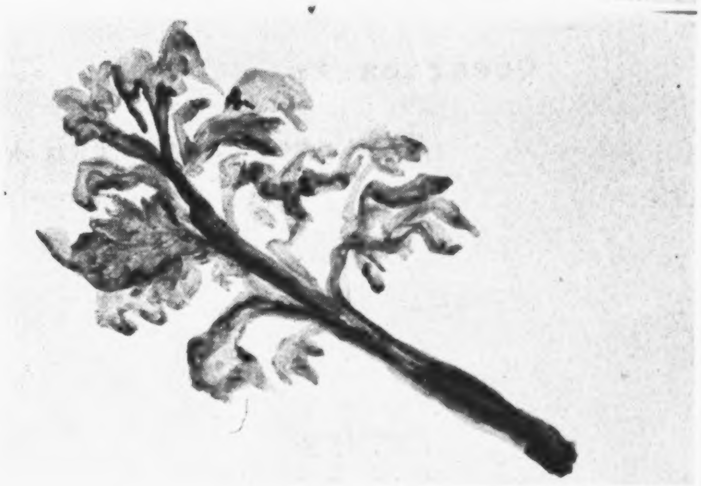


Slide 25

Question D:

What causes celery to wilt in salt solutions? [#25]

ANSWER

This is not specific enough to help plan an experiment or to indicate what information is needed. Better statements might include:

A. Does a salt solution cause wilting through loss of water? (Consider salt solution and loss of water)

B. Does a salt solution soften the fibers of celery to cause wilting? (Consider salt solution and softness of fibers)

STOP--GO TO PART III

NARRATIVE FOR LARGE GROUP, SMALL GROUP OR TAPED PRESENTATION

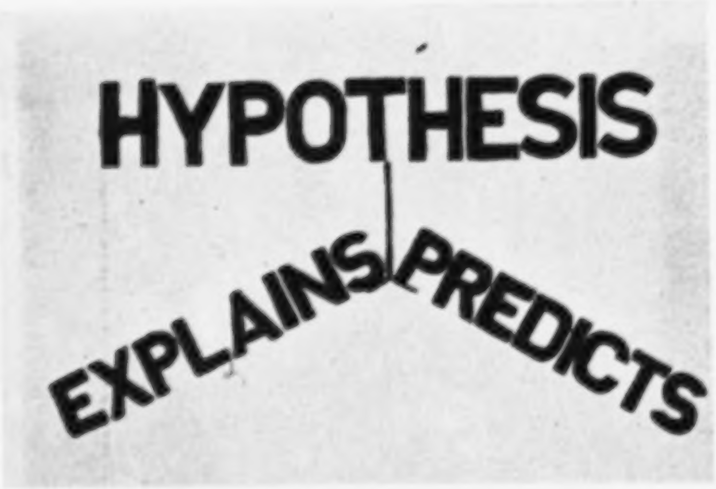
III. Formulating Hypotheses: "If-and-then" Statements

Let us look back at the problem concerning the algae and the two lakes. The Beattys wondered what might explain the fact that Clear Lake has extensive algae and Lake Tahoe does not, as well as how the algae in Clear Lake might be removed or CONTROLLED.

In these problem situations we are looking for "might be's" as tentative solutions to problems. These educated guesses are a part of solving the many kinds of problems that all people face.

Such guiding solutions to problems have a definite name. They are called hypotheses. We can define "hypotheses" in the following way: hypotheses are tentative solutions to a specific problem; they are possible solutions that can account for the known facts, and also predict that certain events have happened or will happen. POSSIBLE EXPLANATIONS AND PREDICTIONS ARE THE TWO FUNCTIONS OF HYPOTHESES. [#26]

GO TO QUESTION 8 ON THE WORKSHEET

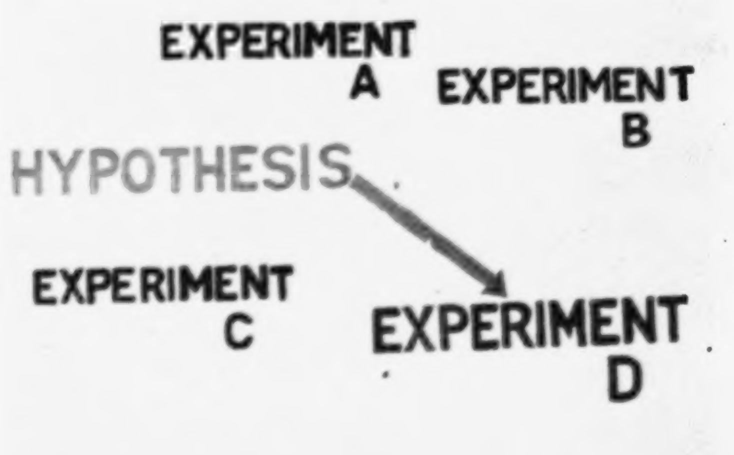


HYPOTHESIS

EXPLAINS

PREDICTS

Slide 26



EXPERIMENT A

EXPERIMENT B

HYPOTHESIS

EXPERIMENT C

EXPERIMENT D

Slide 27

We have already suggested that one of the values of an hypothesis is that once stated, it suggests a way to solve the problem by experimental test. It virtually says what to do. [#27]

For an example of this form, we might take one of the causes Bill Beatty suggested and state it effectively as a problem: Does water temperature affect the presence and growth of algae in Clear Lake? Three alternate hypotheses about this problem would be:

Alternate hypothesis 1: If the water temperature does affect the presence and growth of algae, and the lake is warm (60° or above), then algae will exist and grow rapidly in the lake.

Alternate hypothesis 2: If the water temperature does affect the presence and growth of algae, and the lake is cold (45° or below), then algae will not exist or grow very well in the lake.

Alternate hypothesis 3: If the water temperature does not affect the existence and growth of algae, then algae may thrive in lakes at many different temperatures.

The following questions should help you look more closely at the form of these hypotheses:

GO TO QUESTION 9 ON THE WORKSHEET

"IF" - FOLLOWED BY CAUSE

"AND" - FOLLOWED BY A STATEMENT OF EXISTENT CONDITIONS

"THEN" - CONSEQUENCES WE EXPECT

Slide 28

WHEN ASKED TO STATE A HYPOTHESIS, YOU SHOULD ALWAYS STATE IT IN THE "IF-AND-THEN" FORM; WHERE THE "IF" IS FOLLOWED BY THE CAUSE: AND THE "AND" IS FOLLOWED BY A STATEMENT OF EXISTENT CONDITIONS; AND THE "THEN" IS FOLLOWED BY THE CONSEQUENCES WE EXPECT. EVEN THOUGH THERE ARE OTHER CORRECT FORMS FOR WRITING A HYPOTHESIS, THE "IF-AND-THEN" FORM IS AN EXTREMELY USEFUL WAY OF LEARNING "HOW" TO WRITE A GOOD HYPOTHESIS.[#28]

GO TO QUESTION 10 ON THE WORKSHEET

WORKSHEET TO ACCOMPANY TAPED PRESENTATION
(Or For Use with Groups of Students)

III. Formulating Hypotheses: "If-and-then"

Question 8:

Before considering the form of hypotheses, try to suggest two causes, other than water temperature and altitude, for the extensive growth of algae in Clear Lake, such as Bill Beatty might have suggested to John.

ANSWER

Among many possible causes perhaps you listed: absence of animals which eat algae, presence of more "food" for algae, more stagnant or non-moving nature to lake, presence of algae in streams which feed lake, etc.; also mineral content of water.

STOP-RETURN TO NARRATIVE

Question 9:

A. For all three statements, what word or words come before the "cause" of the problem statement; what word or words comes before a statement of the existent conditions; and what word or words come before the "effect" or prediction about the problem statement?

ANSWER

Notice that in all of our "If-and-then's", the "if" is followed by the suggested cause or condition; the "and" is followed by a statement of the conditions; the "then" is followed by the prediction or the effect or consequence we expect.

B. What is the differnce in the punctuation of the statement of the problem, and the punctuation of any one of the hypotheses?

ANSWER

The statement of the problem is in question or interrogative or question form and is followed by a question mark. The hypotheses are positive or declarative statements and are followed by periods. The hypothesis changes the problem statement from a question to a definite, predicting statement.

C. What is the difference between alternate hypotheses 1 and 2, and hypothesis 3?

ANSWER

A hypothesis is a way of expressing the relationship between a cause and its possible effect. Of the three alternate hypotheses given, the first two predict results if there is a relationship between A and B (water temperature and growth of algae), while the third predicts the results if there is no relationship between A and B.

In the first two cases, the "then" is followed by what we expect to happen under different conditions if the hypothesis is positive or was a "good" guess. In the third case the "then" is followed by what we expect to happen if the hypothesis is negative or a "bad" guess.

STOP-RETURN TO NARRATIVE

Question 10:

Using the same form, state at least two alternate hypotheses for the problem, "Does the altitude of the lake affect the growth of algae in it?"

ANSWER

You should have statements very similar to the following:

Hypothesis 1: If the altitude affects the growth of algae and the Lake is at high altitudes such as Lake Tahoe, then algae will not exist in abundance and will not grow well.

Hypothesis 2 If the altitude affects the growth of algae and the lake is at low altitudes such as Clear Lake, then algae will exist and grow very well.

Hypothesis 3: If the altitude does not affect the growth of algae, then algae may grow well in lakes at many different altitudes.

STOP-GO TO PART IV

NARRATIVE FOR LARGE GROUP, SMALL GROUP,

OR TAPED PRESENTATION

IV. Testing Hypotheses

Once John Beatty had formulated a specific problem (does the altitude affect the growth and presence of algae?) and a hypothesis, (the three alternative forms given in the previous section), the next step would be to test the hypotheses by experiment. Like the problem statement and the hypothesis, an experiment has a particular form to make it effective as a test of the hypothesis.

John's idea shown in his hypothesis, roughly speaking, was "If proper altitude, then algae." But he was assuming something without saying it--that the altitude would be the only difference. If more than one condition were different (for example, both altitude and water temperature), he would not know which of the conditions (or maybe both) brought about the change from clear water to water with extensive growth of algae. The condition that will be systematically changed or varied (tested by varying it) as John varied the altitude is called the VARIABLE.

The other conditions during this test that are not varied but are purposely made to stay the same during the experiment, are called CONSTANTS. Note that the information given about John's experiment stated that the water temperature in the test bottles was the same as the water temperature at Clear Lake during that time.

GO TO QUESTION 11 AND 12 ON THE WORKSHEET

In an experiment to see if water temperature aids the growth of algae, would the water temperature be a variable or a constant? In the same experiment, would the altitude be a variable or a constant?

Was the water temperature the only condition that should have been constant in John's original experiment?

No, all of the possible causes identified as conditions which might affect the presence and growth of algae (listed in section III) should have been held constant.

Arranging an experiment such that one can be reasonably sure that only the condition under test is changed is called controlling an experiment. The result is called a CONTROLLED EXPERIMENT.

If the hypothesis being tested suggests that: "If the water temperature affects the growth of algae, and the water temperature is warm, the algae will grow well," then the water temperature will be systematically varied and will be the variable factor. In the same experiment the altitude would be held constant in all cases. A controlled experiment systematically varies only one condition, the variable. All other conditions, the constants, remain the same to test the relationship between the variable and the observed consequence.

It is very hard to be sure that we have a perfectly controlled experiment. An experimenter tries to control all of the conditions that he has identified through his search for specific problems and their hypotheses. Usually, too, a single problem will result in several independent experiments, each of which tests a different possible cause as the variable with other possible causes held constant.

A way to come closer to complete control--even to control unknown factors, is to change the condition being varied in one performance of the experiment and vary it in another performance. For example, John Beatty could have filled a third clear glass bottle with Clear Lake water and left it at the altitude of Clear Lake. This bottle, then would have been the basis for a comparison of algae growth in the other two bottles. Such a case, where the variable is not changed but kept the same for comparison is called a CONTROL. A controlled experiment systematically varies one condition, the variable, in all but the one case; this case is called the control.

GO TO QUESTION 13 ON THE WORKSHEET

Describe a control for an experiment which would test the hypothesis that water temperature aids the growth of algae.

While several samples were held at temperatures different from the temperature of Clear Lake, one sample would be held at the temperature of Clear Lake.

WORK SHEET

IV. TESTING HYPOTHESES

Question 11:

In an experiment to see if water temperature aids the growth of algae, would the water temperature be a variable or a constant?

ANSWER

If the hypothesis being tested suggests that: "If the water temperature affects the growth of algae, and the water temperature is warm, then the algae will grow well," then the water temperature will be systematically varied and will be the variable. In the same experiment the altitude would be held constant in all cases. A controlled experiment systematically varies only one condition, the variable. All other conditions, the constants, remain the same.

Question 12:

Was the water temperature the only condition that should have been held constant in John's original experiment?

ANSWER

No, all of the possible causes identified as conditions which might affect the presence and growth of algae (listed in Section III) should have been held constant.

STOP--RETURN TO THE NARRATIVE

Question 13:

Describe a control for an experiment which would test the hypothesis that water temperature aids the growth of algae.

ANSWER

While several samples were held at temperatures different from the temperature of Clear Lake, one sample would be held at the temperature of Clear Lake.

STOP

THIS COMPLETES THE PRESENTATION ON THE INQUIRY METHOD.

Biology 1

Inquiry Unit Test

Name ______________________

Period ______________________

Section ______________________

1. Consider the following situations described or pictured below.

   Recognize and state a general problem for each of the following situations.

   Write your answer below each situation.

   A. Mary and Jane are both sophomores at Cubberley, although Mary is shorter and lighter.

   B. Lettuce, which grows well in the Salinas area, is not grown in Madera.

   C. Lima beans, kidney beans and string beans.

   D. Eucalyptus leaves, oak leaves and sycamore leaves.

2. Refer to question 1, parts A through D for the following:

Write an effective problem (be specific) that you recognized for the situations on the previous page. If you are satisfied that the problems are effectively stated in your answer to question 1, then write an "O.K." below. If not, then state the problem effectively.

A.

B.

C.

D.

3. Among the following problem statements, some are stated so that they are effective while others are not and are just recognition of problems. Identify those that you think are effectively stated by placing the letter "E", and identify those that you think are ineffectively stated by placing the letter "I" in the middle column. Then state the reason why you think they are effective or ineffective.

E = effective
I = ineffective

PROBLEM STATEMENT	"E" or "I"	REASON
A. Why does a desert have very little vegetation?		
B. Do the effects of exposure (wind and/or snow) affect cell growth in Jeffery pine trees?		
C. Why do oak trees and pine trees differ?		
D. How do students learn biology?		
E. Does the amount of nitrogen in the soil affect the growth of lettuce?		

4. Let us assume that your family has moved to a summer home at Lake Tahoe, California from your home at Palo Alto. Soon after your arrival at Lake Tahoe, you and your twin brother develop the same illness. You both have red runny noses, swollen tongues, and watery eyes. Then you both return to Palo Alto for a weekend, and your illness disappears overnight. When you go back to Lake Tahoe on Monday, the illness again appears.

   A. Identify three possible causes for this condition.

      (1)

      (2)

      (3)

   B. There are three alternative ways of stating the same hypothesis. Using the "if-and-then" form, state these alternatives for one of the causes you have identified above.

      (1)

      (2)

      (3)

5. Imagine yourself to be a famous biologist. A California winemaker calls you in to help him. Some of his wine has been the best in California, but some of it has turned into vinegar.

    (1) Recognize the general problem facing you.

    (2) Write an effective problem statement.

    (3) State a hypothesis for the problem in the "if-and-then" format.

    (4) Describe how you would test your hypothesis using a controlled experiment.

6. A student was interested in the effect of salt on gold fish. He obtained three fish from the same litter and placed them in three identical bowls. He added no salt to the first bowl, five (5) grams of salt to the second bowl, and ten (10) grams of salt to the third bowl. He adjusted all three bowls to the same water level. All three bowls were placed and remained in the same laboratory.

Various parts of this experiment have been listed below. You are to identify whether the parts listed are variables, or constants, or controls for the experiment. Place a "V" in front of the variable(s), a "CT" in front of the constant(s), and a "CO" in front of the control(s).

__________ salt

__________ goldfish

__________ bowl

__________ level of water in bowls

__________ 5 grams of salt

__________ no salt

AN INSTRUCTIONAL PACKAGE
FOR A UNIT ON
MATTER AND ENERGY
FOR BIOLOGY STUDENTS

Prepared by the Staff
of the
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Matter-Energy Unit

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Introduction - General

The purpose of the Matter-Energy package is to give high school students experience with conceptual models by examining biochemical processes on a molecular level. Specifically the kinetic-molecular model of matter and energy will be extended to a model of chemical reactions. The model will be used to explain and examine the nature of fats, carbohydrates, and proteins; the action of enzymes and adenosine triphosphate; and fermentation and protein synthesis. The use and extension of conceptual models will result in student ability to predict behaviors or capabilities of a living system through use of the given model.

Teacher Rationale

The Matter-Energy unit is designed to be preceded by a study of the nature of conceptual models. Within the unit conceptual models for matter, energy and chemical reaction are presented and then used to interpret microscopic data as molecular-chemical phenomena. The major intent is to provide the student with a conceptual tool that he can use as he studies physiological functions and anatomical structures of unicellular and multicellular organisms.

The connection between observations and the conceptual models is given major emphasis so that students realize that models must fit and explain observed data. This helps students to understand how the model emerged. Once the model exists, it can then be used to predict and interpret additional data. For this unit the prediction and interpretation has been built around the biochemical topics of DNA, ATP, fermentation, enzyme function, and the general synthesis and separation reactions that occur within living systems. There is a distinct effort to reveal the general patterns rather than immerse the student in too much detail.

The terminal behavioral objective for this unit and the related previous behavioral objectives include:

a. to predict behaviors or capability of performance of biochemical systems on the basis of a given conceptual model for chemical reaction.
b. to list the assumptions (properties) of the matter energy model.
c. to recall observations which led to assumptions.
d. to describe the matter-energy model.
e. to explain observed phenomena of matter-energy in terms of the model.

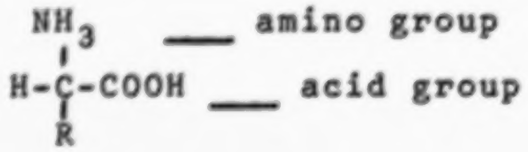
Instructional Objectives

- Given a general chemical equation, the student will discriminate between the reactants and products, in terms of energy increase or decrease and change in matter.
- The student will be able to identify and list four life processes which involve changes in energy-matter.
- Given a chemical equation in which certain products have been left out, the student will identify those missing products in terms of change in matter and energy.

  e.g.: $E_1 + COH \longrightarrow CO + E_1 + \underline{\quad}(H)$

- The student will be able to discriminate between the structural formulas for: protein, fats, starches, and sugars.
- Given multiple choice questions, the student will be able to discriminate the properties of atoms, molecules, chemical bonds, and enzymes.
- Given structural formulas for proteins, sugars, starches, and fats, the student will be able to identify the characteristic (unique, distinguishing) properties of each of these organic structures.

  e.g.: protein



$$\begin{array}{c} NH_3 \\ | \\ H-C-COOH \\ | \\ R \end{array}$$

- In multiple choice questions, the student will recognize the following characteristics of enzymes from descriptions or statements: components, functions, type of reactions controlled by enzymes, the relation of temperature to enzymes.
- From comparative descriptions of organic reactions, the student will be able to identify if a particular reaction is:

  A. Synthesis or separation
  B. Influenced by the presence of an enzyme

- Given that energy or matter has been added to or subtracted from reactants, the student must correctly identify the resultant change in matter or energy.

  For example:

  (1) Sugar A + $E_1 \longrightarrow$ ______
  - a. Sugar A
  - b. Sugar B + E_1 ($E_1 = E_1$)
  - c. Sugar B
  - d. No change (Sugar A + E_1)

  (2) □ + $E_1 \longrightarrow$ ______
  - a. □
  - b. ○
  - c. ○ + E_1
  - d. No change (□ + E_1)

- Given equations showing protein synthesis (or sugar synthesis or sugar-starch conversion), the student can interpret that (1) a protein has been formed, (2) energy has been stored, and (3) the energy in such a reaction (organic) comes from ATP in a living system and heat.

  e.g.: Amino Acid + Amino Acid $\longrightarrow$ Simple Protein

  A. What has been formed? ________(protein)

  B. Has energy been stored? ________(yes)

  C. What is the immediate source of this energy? ________(ATP, heat)

- The student must be able to associate the symbols C, H, O, N, P with the names of the appropriate element.

- Given a structural formula, the student can identify chemical bonds, elements, and their arrangement in three dimensions.

- The student recognizes that temperature affects the form and existence of proteins and responds to multiple choice descriptions accordingly.

  Example: An egg, placed in boiling water for five (5) minutes changes its form. This may be explained by:

  1. Starch changes to sugar
  2. Sugar changes to starch
  3. Protein structure is changed
  4. Proteins are made
  5. Proteins are destroyed
  6. None of these

Biology 1

Kinetic Molecular Model

Name ____________________________

Period _____

- I. Introduction
  - A. Physical and chemical changes
  - B. Common properties of life
  - C. Models
    - 1. Function
    - 2. Properties
- II. Kinetic Molecular Model
  - A. Forms of matter (complete chart)
  - B. Gelatins
  - C. Elements
  - D. Compounds
  - E. Atoms
  - F. Molecules
  - G. Chemical symbols: C, O, H, N, S, and P
  - H. Compounds: H_2O, CO_2, NH_3, and CH_4
  - I. Energy
    - 1. Heat
    - 2. Potential
    - 3. Kinetic
    - 4. Chemical
- III. Review of Assumptions of Kinetic Molecular Model
  - A. Assumption 1
  - B. Assumption 2
  - C. Assumption 3
  - D. Assumption 4

Biology 1
Chemical Reaction Model

Name ____________________
Period _____

I. Use of kinetic energy model

II. Basic kinds of chemical reactions in living organisms

III. Chemical reaction model

A. Use of symbols

B. Representation of a synthesis reaction:

$$E_1 + A + B \longrightarrow C$$

1. Squares

2. Letters

3. Arrow

4. E_1

5. Reactants

6. Products

C. Representation of a separation reaction:

$$C \longrightarrow A + B + E_1$$

IV. Applying kinetic energy model to chemical reaction model

A. Is there a loss or gain of atoms during a chemical reaction?

B. How does the concentration of reactants and the amount of available surface area affect the rate of chemical change?

C. How does the shape of the molecules and the position of the reactive points affect reactions? Do all collisions of molecules lead to reaction?

D. How does temperature affect chemical reactions?

E. Where is the energy in a molecule formed from a synthesis reaction?

F. Is there a loss or gain of energy during a chemical reaction?

iology 1 Name ______________________

olecules of Living Organisms Period _____

I. Introduction

A. Complexity

B. Structural and molecular formulas

C. Organic compounds

I. Major Categories

A. Carbohydrates

1. Function

2. Components

3. Composition

4. Structure

5. Examples

B. Fats

1. Function

2. Components

3. Composition

4. Structure

5. Examples

C. Proteins

1. Function

2. Components

3. Composition - Amino Acids

a. Function

b. Components

c. Composition

d. Structure

4. Structure

        5. Examples
        6. Graphic Structure
        7. Changes in protein
III. Enzymes
    A. Introduction
    B. Function
    C. Components
    D. Properties
    E. Synthesis Reaction
    F. Separation Reaction
    G. General Properties of enzymes

PRE-TEST: MATTER/ENERGY PACKAGE

Name ______________

Date ______________

Period ______________

Section ______________
I or C

Instructions:

The purpose of this test is to determine how much you already know about the material you are going to study. The score which you receive has no influence on your semester grade. Nevertheless, it will benefit you to work as accurately as possible on the test. You will have ample time to finish all questions.

You are to read each test question carefully, and then indicate the correct answer by placing a check (✓) next to the letter which indicates the correct answer. With the exception of question 13 follow these instructions throughout the test. For Question 13, follow the instructions in the question. Below is an example question and its correct answer.

Example:

San Francisco is: ____.

___ a. Country
___ b. State
_✓_ c. City
___ d. Town

1. Which of the following descriptions is an example of potential energy?

___ a. The movement of a swimmer in the water.

___ b. The heat from the sun.

___ c. An automobile moving on the freeway.

___ d. The wood stacked up in a fireplace.

2. Which of the following does not represent a principal state of matter?

___ a. Liquid

___ b. Solid

___ c. Gel

___ d. Gas

3. The chemical symbol, C, represents:

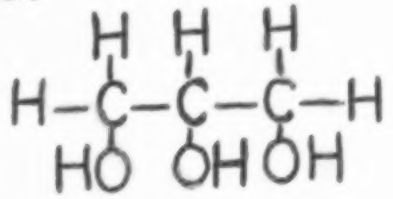
___ a. The element californium

___ b. The element carboridium

___ c. One atom of carbon

___ d. One molecule of carbon

4. The -OH group, found in three places in the formula below, represents:



___ a. An oxygen atom bonded to a hydrogen atom.

___ b. A water molecule.

___ c. A molecule which is rounded on one end and has two prongs on either side of the other end, resembling the letters "O" and "H".

___ d. The fifth and eighth kinds of molecules to be discovered.

5. In the reaction below, glycine (CNH_5COOH) is

$$E + NH_4 + CH_3COOH \longrightarrow CNH_5COOH + H_2$$

___ a. Synthesized

___ b. Separated

___ c. Neither

6. Based on the chemical equation below, the product(s) are:

$$C_6H_{12}O_6 \longrightarrow 2C_2H_5OH + 2CO_2 + \text{Heat}$$

___ a. $C_6H_{12}O_6$

___ b. $C_6H_{12}O_6$ and $2\ C_2H_5OH$

___ c. $2CO_2$

___ d. $2C_2H_5OH$

___ e. $2C_2H_5OH$, $2CO_2$ and Heat

7. Predict the product(s) in the following reaction:

$$\text{Molecule M} + E_1 \longrightarrow \underline{\qquad}$$

___ a. Molecule M

___ b. E_1

___ c. Molecule O

___ d. Molecule O + E_1

8. Predict the reactant(s) in the following reaction:

$$\underline{\qquad\qquad\qquad} \longrightarrow \text{Molecule O} + E_1$$

___ a. E_2

___ b. Molecule P + E_1

___ c. Molecule O

___ d. Molecule M

9. The molecules or particles which have the most chemical energy in a synthesis reaction are:

___ a. The reactants

___ b. The products

___ c. Neither

10. In the equation below, which is the most complex molecule or particle?

$$2H_2O \text{ \_\_\_\_\_ } 2H_2 + O_2$$

___ a. H_2

___ b. $H_2 + O_2$

___ c. H_2O

___ d. $H_2O + O_2$

11. Which of the following are life processes that involve the separation or synthesis of organic molecules?

___ a. Photosynthesis

___ b. Respiration

___ c. Fermentation

___ d. All of the above

___ e. None of the above

12. The molecule $C_3H_5(C_{15}H_{31}COO)_3$ would be classified as a _____.

___ a. Carbohydrate

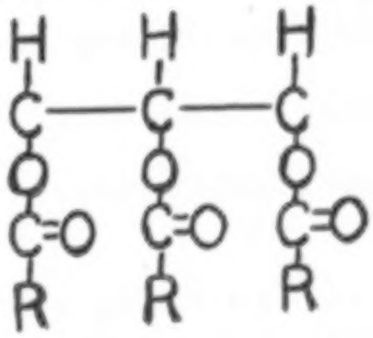
___ b. Fat

___ c. Protein

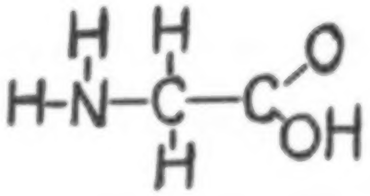
___ d. Amino acid

___ e. None of the above

13. On the following structural formula, circle the letters for the fatty acid group and label them with the letter E. Circle the letters for the glycerol group and label them with the letter G.



14. The organic molecule represented by the structural formula below would be a ___.



$$\mathrm{H{-}N(H){-}C(H)_2{-}C(=O)OH}$$

___ a. Fat

___ b. carbohydrate

___ c. Protein

___ d. Vitamin

___ e. None of these

15. All enzymes are composed, in part, of:

___ a. Fats

___ b. Sugars

___ c. Proteins

___ d. Starches

___ e. None of these

16. The temperature at which enzymes are most effective is ___.

___ a. Room temperature

___ b. 50° Centigrade

___ c. Body temperature

___ d. 10° Centigrade

17. Four of the following statements about enzymes are true. Which one is false?

___ a. Enzymes cannot function without vitamins.

___ b. Enzymes can function after being separated from an organism.

___ c. Enzymes affect one particular chemical reaction.

___ d. Enzymes can be used over and over again.

18. In a chemical reaction, enzymes _______.

___ a. Provide needed energy to reactants.

___ b. Allow reactions to occur which would not otherwise occur at all.

___ c. Change the rate of reactions.

___ d. Release energy.

19. The energy associated with a change in matter, if it occurred in a living organism, would be in the form of _____.

___ a. Heat

___ b. ATP ADP ATP

___ c. Random motion of molecules

___ d. Light

20. The energy required for the synthesis of complex molecules from simple molecules in a living organism, comes primarily from _____.

___ a. Enzymes

___ b. ATP

___ c. Heat

___ d. ADP

___ e. None of these.

NARRATIVE FOR LARGE GROUP, SMALL GROUP, OR TAPED PRESENTATION

MATTER-ENERGY UNIT

Part I: Sensory Bombardment

This unit is going to begin with a series of experiences that will require you to use your senses. You will make pertinent observations about a variety of situations that deal with matter and energy. The sampling that you will encounter during this period of study should be examined by you in such a way that you can initiate three activities.

First, you need to observe all the situations in the film. Once you have gone through all of them, go over them again more slowly and make notes on what you see in each situation. Your observations should be especially concerned with a description of the matter or material that is present, the conditions the matter is subjected to, and the changes that occur. Use all your senses (sight, sound, smell, touch, and taste) to gather your observations.

After completing your notes on the filmed situations, go to the direct observation situations; follow the directions and note the results.

As a continuation assignment, state a specific, investigatable problem about each situation. Sample observations are recorded for the first situation, and problems for it are stated as examples, for you to follow.

The experiences encountered in this lesson will serve as a basis for discussion and reference in the study of matter and energy in living organisms during the study of this unit.

WORKSHEET--Page 1

Situation Observed	Observations	Problem Statement
1. Film clip: Dropping an Alka-Seltzer tablet into water	The water becomes cloudy with tiny bubbles. A foam gathers on the water surface. The tablet grows smaller and disappears. Some of the time, the tablet floats and then it sinks.	Do the bubbles come from something in the tablet? Or do they come from the water because the tablet is there? Do all the bubbles escape from the water?
2. Film clip: Hydrogen peroxide reaction in absence and presence of liver extract		
3. Film clip: Growth of yeast under two sets of temperature conditions		
4. Film clip: Gym student on the trampoline		

WORKSHEET--Page 2

Situation Observed	Observations	Problem Statement
5. Film clip: Gym student doing weight lifting		
6. Film clip: Roasting of a sample of sugar, meat and fat in a flame		
7. Film clip: An aquarium pump and a closeup of the fish in the aquarium		
8. Film clip: Styrofoam ball and metal slug suspended to counter-balance each other		

WORKSHEET--Page 3

Situation Observed	Observations	Problem Statement
9. Film clip: Egg frying on a griddle and fat splattering		
10. Film clip: Radiometer without light shining on it and with light beam on it.		
11. Film clip: Leaves with dappled sunlight shining on them		
12. Film clip: Electrolysis of water		

Situation Observed	Observations	Problem Statement
13. Film clip: Burning as it occurs in air and as it occurs in concentrated oxygen (a test for oxygen)		
14. Film clip: Testing for hydrogen and the products of its combustion		
15. Film clip: Solid ammonium chloride put into water		
16. Film clip: Concentrated sulfuric acid put into water		

WORKSHEET--Page 5

Situation Observed	Observations	Problem Statement
17. Film clip: Air trapped in a container		
18. Film clip: Lighting candle and bunsen burner		
19. Film clip: Ice cubes melting in a beaker		
20. Film clip: Gelatin mass		

WORKSHEET--Page 6

Situation Observed	Observations	Problem Statement
21. Film clip: Rabbit neck muscle and ATP		
22. Film clip: Centrifuged blood		
23. Energy and molecules Film clip:		
24. Direct observation: Bubble your breath through limewater solution in a test tube. Do so for at least one minute.		

Situation Observed	Observations	Problem Statement
25. Blow up a balloon		
26. Direct observation: Place a drop or two of alcohol on the back of one hand and wave it around. Place a drop of water on the other hand and wave it around.		
27. Direct observation: Soak the cotton with perfume and let it stand at the corner of your desk.		
28. Direct observation: Take a bite of the soda cracker and chew it very thoroughly without swallowing.		

NARRATIVE FOR LARGE GROUP, SMALL GROUP

OR TAPED PRESENTATION

MATTER-ENERGY UNIT
PART II: KINETIC-MOLECULAR MODEL

The observation of many examples of the interaction of matter and energy supplied you with a variety of sensory experiences. The short time interval and the large number of experiences presented may have seemed chaotic and confusing. You need a means for making the experiences meaningful and orderly.

The observations that you made and the problems that you identified were concerned primarily with the physical and chemical changes of matter. These physical and chemical changes of matter are an important part of the study of biology. Recent major advances in the understanding of biology have been made in these two areas.

Although life exists in great variety, all organisms or life systems have a number of things in common. [#1]* One of these similarities is composition. All living organisms are composed of matter. Matter reaches a highly organized form when it is part of a living system. However, it is still the same matter found in the non-living world. The yeast cells, the fish, and the weightlifter and his weights that you observed are all made of matter.

The use of energy is another common quality of all life. Energy is essential to an organism in order for it to carry out the functions that make it a living system. The yeast cells' activity with sugar was directed toward obtaining energy. One way to describe life is that it is a matter-energy system that is organized so that energy can be used to carry on life processes. Death results when the release and use of energy ceases.

Although living forms have other qualities of life in common, in this unit we will limit our study to matter and energy. Keep in mind that an understanding of the nature of matter and energy is essential to an adequate understanding of biology.

During this unit two models, such as the model used in the population study, will be developed. The first model deals with the nature of matter and energy, and the second model will be used to explain the changes and interactions of matter and energy in living systems. You will then use these models to explain the phenomena of the sensory bombardment and to explain the reactions of matter and energy in living systems.

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* Numbers refer to slides

The model, which we will use to think about matter, must serve the functions of a hypothesis. That is, it must *explain* the observed characteristics or properties of the matter-energy system and it must *predict* the effect of changes on the matter-energy system. Notice that we are not only concerned with the *present* condition of the system, but also with *future* states which are the result of changes. Changes constantly occur in living organisms, so our model must help us predict and explain the results of such changes. We will call the properties of the model assumptions.

What observations can lead to a picture of matter? A direct examination of "things" around you with special attention to living organisms indicates that material substances can be grouped into three major categories: solids, liquids, and gases. [#2] Solids are identified by their ability to retain their shape. Liquids and gases are identified by the fact that they assume the shape of their containers. Liquids and gases differ by the fact that liquids cannot be easily squeezed or compressed into smaller containers, while gases are easily compressed.

Common Properties of Organisms

(1) Composition: all organisms are composed of matter

(2) Energy: all organisms use energy to carry out life functions

Slide 1

Properties of Matter

(1) Solid: Ability to retain shape

(2) Liquid: (a) takes shape of its container and (b) cannot be easily squeezed into smaller containers

(3) Gas: (c) can be easily compressed or squeezed into a smaller container

Slide 2

Observations such as those summarized in Table I, [#3] led early Greek scientists to assume that matter was made up of tiny, invisible particles. Such particles occupy space and have differing amounts of space between them. The collective weight of the particles is the weight of the substance. The particles can vary greatly in size and weight. Particles of solids and liquids are close together, whereas gas particles are far apart. Particles in solids are held in position. Particles of liquids and gases are free to move and flow.

	SOLID	LIQUID	GAS	GEL
1. Shape and form				
2. Weight (Mass)				
3. Fluidity				
4. Volume				
5. Compressibility				

Student worksheet, to be used before viewing Slide 3.

Table 1: Properties of Matter

		Solid	Liquid	Gas
1.	Shape and form	Definite determined by substance	Determined by container	Determined by container
2.	Weight (Mass)	Yes	Yes	Yes, but small in comparison with solids and liquids
3.	Fluidity	No-rigid	Yes	Yes
4.	Volume	Yes	Yes	Yes, but widely variable
5.	Compressibility	No	No	yes

Slide 3

We now have two assumptions about matter which are the beginning of a model. [#4]

ASSUMPTION 1: All matter is composed of tiny, invisible particles which have weight.

ASSUMPTION 2: Such particles occupy space and have differing amounts of space between them.

Slide 4

This model helps us consider the special cases of substances like gelatin and the fluid portion of blood. Gelatins, as seen in film clip #20, and protoplasm, the substance inside cells, are called gels and have characteristics which lie between solids and liquids. Some of the particles are held in rigid association as in solids while others are free to move, as in liquids. Solutions, such as the fluid portion of the blood seen in film clip #22 are described as a mixture of particles of the liquid.

TURN TO SELF-CHECK 1 OF YOUR WORK SHEET Remember to stop the tape player until you have finished the first self-check.

The early Greek scientists recognized that matter was not all the same. While Aristotle felt that all matter was some combination of fire, earth, air, and water, many later experiments suggested that air was not a simple kind of substance. Observation and experiment have shown that there are many kinds of "air", or GASES which can be identified.

By the seventeenth century, chemists had concluded that two major kinds of matter existed--elements and compounds. [#5] In the view that they presented, elements are the ultimate kinds of matter; they cannot be divided into simpler substances, nor can they be changed into one another. Compounds are composed of two or more elements united to make new substances different from the elements; compounds thus have properties that are different than the properties of the elements of which they are composed. Substances like air are mixtures of elements and compounds. Such mixtures do not have new properties of their own as compounds do.

Our third assumption summarizes this information as another property of our model. [#6]

ASSUMPTION 3: (a) Particles called elements can combine to form compound particles, and (b) the particles of both elements and compounds have properties of weight and volume that are unique to each element and each compound.

Definitions: Element, Compound and Mixture

(1) Element: The simplest kind of matter; it cannot be divided into simpler substances

(2) Compound: Composed of two or more elements; a compound has properties different from the properties of the elements of which it is composed

(3) Mixture: Composed of both elements and compounds, but does have new properties

Slide 5

Assumption 3:

(a) Elements can combine to form compounds

(b) Both elements and compounds have properties of weight and volume characteristic of each element and each compound

Slide 6

The particles of elements are called atoms. There are 103 known elements at present; the atoms of each element differ in properties from the atoms of the other elements. Atoms unite to form complex particles called molecules. Molecules may be made of atoms of the same element or the atoms of several elements. Many, but not all compounds are made of molecules.

Symbols can be used to represent the elements and their atoms; a particular symbol can be used to represent each kind of atom. Then, the symbols for compounds can be made by putting the symbols for atoms together. The complex symbol for the elements in the compound and how many atoms of each element, is often called a chemical formula. Some of the most common elements in living organisms and their symbols are summarized in slide [#7]. Study this list before you continue with the tape-slide presentation.

Notice in these formulas for compounds that the symbols for the elements are followed by a subscript number to indicate the number of that kind of atom in the compound, if it is greater than one. Thus, a molecule of the compound water, H_2O, is made up of two atoms of hydrogen and one atom of oxygen.

Elements and Compounds

Elements	Compounds
H- hydrogen	H_2O- water
O- oxygen	CO_2- carbon dioxide
C- carbon	CH_4- methane
N- nitrogen	NH_3- ammonia

Slide 7

TURN TO SELF-CHECK 2 OF YOUR WORKSHEET

Observations led early scientists to one more assumption about matter. It was found that the organization or form of matter can be changed by addition or subtraction of heat energy. Thus, solids melt and liquids evaporate when heat is added; gases condense to liquids and liquids freeze to solids when heat is subtracted.

Moreover, the particles of solids, liquids, and gases move apart to occupy more volume when their temperature is raised. The change is especially large for gases. Gases, liquids and solids represent different forms of physical association of atoms and molecules. The atoms and molecules are close together as solids and very far apart as gases. Heat alters the nature of this association. The application of heat forces particles to move apart such that it can be said, the greater the heat, the greater the distance between particles.

Heat is known as one form of energy. There is no way for us to directly feel, see, or otherwise sense energy; we can only detect energy as it affects matter. We can sense the light and heat of a fire produced by a bunsen burner; we can see the movement of a person on a trampoline and the movement of a radiometer placed in the light. Energy does not have a tight, secure definition any more than does the word, "love".

TURN TO SELF-CHECK 3 IN YOUR WORKSHEET

Although it is difficult to define, we can classify energy into two useful categories. The first kind arises from the fact that matter in motion has energy. Moving objects do things to other matter when they collide. Automobiles that have been in accidents show the results of this energy. Air molecules inside a balloon can push on the balloon forcing it to expand. The type of energy associated with motions is called Kinetic Energy. The temperature of the matter is an indicator of the amount of kinetic energy the molecules have. [#8]

Forms of Energy

(1) Kinetic energy: Matter in motion has energy; energy as motion

(2) Potential energy: The position of matter is such that a force can act on it to cause it to have motion; potential for motion

Slide 8

The second kind of energy is due to the position of matter so that a force can act on the matter to cause it to have motion. The most familiar force around us is the earth's gravity. A book on a shelf has energy of position in relation to the floor because gravity can act on it. Since its energy is only potential in nature, this kind of energy is called Potential Energy. If a book is pushed off the shelf, it falls. As it falls, its potential energy becomes kinetic energy.

Robert Brown, a Scottish doctor, noticed that tiny pollen grains in water were constantly in motion when he viewed them with a microscope. This motion, called Brownian motion, suggested to him that the molecules of water must be moving, colliding with each other and with the pollen grains. In film clip #23, a mechanical vibrator was used to give motion to visible particles similar to the motion that Brown suggested for water molecules. Heat, a form of energy, affects this particle motion. If the motion increases, each particle takes up more space. The increased motion also makes the molecules push against each other. Each takes up more space because of its motion.

From the earliest cave man to the present rocket scientist, man has been aware that some kinds of matter release more heat and light (energy) than others. Hence, gas from marshes, called methane, was recognized as a fuel, while water was not. Likewise a warrior or an athlete needing quick energy eats honey, candy or fruit, rather than celery, carrots or lettuce.

The energy obtainable from these fuel and food substances is a form of energy called Chemical Energy. When these substances are burned or digested, the energy in them is released. When it is changing and causing change, chemical energy can be thought of as kinetic energy. When it is a part of fuel and food molecules, it can be thought of as potential energy. [#9]

ASSUMPTION 4: Molecules and atoms have two forms of energy. Motion gives them kinetic energy; chemical energy obtainable from fuel and food molecules is potential energy. Potential energy can be converted to kinetic energy when the molecules are changed.

Our model of the matter-energy system is now complete. It consists of four assumptions [#10]:

Assumption 4:

(a) Molecules and atoms have two forms of energy
(b) Motion gives molecules and atoms kinetic energy
(c) Chemical energy stored at rest in fuel and food molecules is potential energy
(d) Potential energy can be changed into kinetic energy when molecules are changed.

Slide 9

I. All matter is composed of atoms which have weight.

II. These atoms occupy space themselves and have differing amounts of space between them.

III. (a) Particles of elements can combine to form compound particles, and (b) the particles of both elements and compounds have properties of weight and volume that are unique to each element and each compound.

IV. Molecules and atoms have two forms of energy. Motion gives them kinetic energy; chemical energy stored in fuel and food molecules is potential energy. Potential energy can be converted to kinetic energy when the molecules are changed.

Slide 10

TURN TO SELF-CHECK 4 IN YOUR WORK SHEET.

WORK SHEET TO ACCOMPANY TAPED PRESENTATION

(Or for Use with Group Presentations)

MATTER-ENERGY UNIT

Instructions

The purpose of this Worksheet is to provide you with questions which will help you to check your understanding of the material presented. These questions have been provided for your own benefit; they will not be graded. They will be of no help if you do not answer them, nor will it help if you look at the answers before you have attempted an answer. The questions follow the sequence of information presented on tape and slides.

To use the Worksheet, begin by covering the answers on the page. Then read the first question and answer it as accurately and as briefly as possible. Once you have answered the question, check your answer with the answer provided. If you have answered the question correctly, proceed to the next question. However, if you have made a mistake or cannot answer the question, ask the teacher for help. You may need to listen to the tape-slide presentation again. Continue through all of the questions of the Self-check. At the end of a Self-check section, you will return to the tape-slide presentation unless otherwise instructed. Below is an example question.

ANSWER (to be covered)	QUESTION
A biologist studies life in all of its forms.	1. What does a biologist study?

MATTER-ENERGY UNIT
Part II

WORKSHEET

ANSWER	QUESTION
	Self Check 1.
All living organisms are composed of matter. All living organisms use energy.	1. What do all living organisms have in common?
It is more highly organized, and it is organized to use energy.	2. How is "life matter" different from non-life matter?
Organisms must use energy to carry out necessary life functions.	3. Why is energy essential to a living organism?
It is a mental picture that is used to build an explanation and an understanding of many, seemingly different, unrelated observations.	4. What is a model in the way the word is used here?
The first is a mental picture of the nature of matter and energy. The second is a "reaction" model that will help to picture the changes in matter that occur in living systems.	5. What two models will be used in this study of matter and energy?

MATTER-ENERGY UNIT
II WORKSHEET

ANSWER	QUESTION
It must help to explain and to predict.	6. What two functions must the model for matter and energy help us to perform?
It will allow us to suggest the future condition of an organism as a result of changes.	7. Why do we want the matter-energy model to provide a basis for prediction?
Gases.	8. Which form of matter is easily compressed?
Solids.	9. Which form of matter has definite shape?
There is much empty space between particles. Thus, they can be pushed closer together.	10. Why are gases so compressible?
Particles of liquids are not held close to each other.	11. Why can liquids flow so easily?
They are substances that have some properties similar to solids and some similar to liquids. Thus they are semi-solid and semi-liquid.	12. What are gels?

ANSWER	QUESTION
	13. Complete a fifth column for Table 1 by commenting on the properties of gels.
-Slight tendency to hold shape; easily deformed.	Line 1: Shape and form
-Yes, similar to liquid and solids in magnitude.	Line 2: Weight
-Does tend to flow and take the shape of the container.	Line 3: Fluidity
-Yes, again similar to solids and liquids in packaging.	Line 4: Volume
-No, particles already close together.	Line 5: Compressibility
The water contains a great many more molecules per cubic foot than the air.	14. Why is a cubic foot of air so much lighter than a cubic foot of water?

! S T O P !

CONTINUE THE TAPE-SLIDE PRESENTATION

	Self Check 2
Elements are simple or elemental substances that cannot be divided into simpler matter. Compounds are more complex than elements. They are made of two or more elements.	15. How are elements different from compounds?

ANSWER	QUESTION
Mixtures do not have distinguishing properties as do elements and compounds.	16. How does a mixture differ from elements and compounds?
Each kind of atom has a unique volume and a unique weight.	17. How do the atoms of one element differ from those of another element?
They are complex particles made of two or more atoms.	18. What are molecules?
Symbols are used as a shorthand way to represent elements and compounds.	19. How does our model for matter use symbols?
Called a formula, it is made by putting the symbols for its component elements together; it shows the relative number of each kind of atom found in the compound.	20. How is the symbol for a compound made?

ANSWER	QUESTION
O = oxygen C = carbon N = nitrogen H = hydrogen	21. Give the symbols for the following elements: oxygen ____ carbon ____ nitrogen ____ hydrogen ____
Subscripts can be used to tell relative number of each kind of atom in a compound.	22. Why is a subscript made a part of some formulas for compounds?
Carbon and hydrogen.	23. What elements are indicated by the molecular formula for methane, CH_4?
A molecule of methane contains one atom of carbon and four atoms of hydrogen.	24. How many atoms of each type are in a molecule of methane?
The molecule of methane would weigh more since it contains an atom of carbon plus atoms of hydrogen which also have weight as a property.	25. Which would weigh more, an atom of carbon or a molecule of methane?

! STOP !

CONTINUE THE TAPE-SLIDE PRESENTATION

ANSWER	QUESTION
	Self Check 3.
	26. What does the application of heat do to:
A. It expands them and melts them.	A. Solids
B. It expands them and evaporates them.	B. Liquids
C. It expands them.	C. Gases
It is intangible; it cannot be seen, felt or sensed in any direct way.	27. Why is energy so hard to define?

! STOP !

CONTINUE THE TAPE-SLIDE PRESENTATION

	Self Check 4.
It is energy of motion.	28. What is kinetic energy?
They exert pressure because they are in constant motion due to their kinetic energy. The motion causes collisions among molecules and with the sides of a container to produce the pressure.	29. How are molecules of a gas able to exert pressure?

MATTER-ENERGY UNIT
II WORKSHEET

ANSWER	QUESTION
It is energy of position. The position has to be such that a force will cause the object to move if the force can act or is not counterbalanced.	30. What is potential energy?
	31. In each of the following examples identify what is being observed as either an example of potential energy (use P.E.) or kinetic energy (use (K.E.):
A. P.E.	A. Film clip 4- student at highest point above trampoline (no motion), _____
B. K.E.	B. Film clip 4- student while falling to trampoline _____
C. P.E. (Chemical Energy)	C. Film clip 6- sugar in test tube before being burned ____
D. K.E.	D. Film clip 23- moving beads in glass chamber. _____
He saw that pollen grains were always jiggling in a way that suggests that they are bombarded by smaller particles.	32. What observations led Robert Brown to the idea that molecules of water are in motion?
Hot particles are moving faster and because of their motion, they fill more space.	33. Why do hot particles take up more space than the same number of cooler particles?

MATTER-ENERGY UNIT
II WORKSHEET

ANSWER	QUESTION
Good food and fuel substances contain large amounts of chemical energy that can be changed to kinetic energy.	34. What kind of substance makes a good food or fuel?
1. The substance is a compound made of three kinds of atoms. 2. Each atom has weight and volume which contribute to the total weight and volume of the molecule. 3. The atoms of carbon, hydrogen and oxygen combine to make this molecule, which has a set of properties different from the properties for each element. 4. The molecule may be a source of chemical energy. 5. The molecules of C_2H_6O have kinetic energy or motion energy.	35. Use the four assumptions of our model for matter to build a description of the substance, ethyl alcohol, which has the formula C_2H_6O.
At higher temperatures, the gas molecules move faster and thus hit harder and more frequently. The result is higher pressure or the filling of more space.	36. Gases exert "push" or pressure in al directions. The pressure increases as the temperature increases. How does the model explain this behavior

REVIEW, AND/OR
CONTINUE BY LISTENING TO TAPE OF
PART III

NARRATIVE LARGE GROUP, SMALL GROUP, TAPED PRESENTATION

MATTER-ENERGY PACKAGE
PART III: CHEMICAL REACTION MODEL

Now that we have our general model of matter, we will apply it and its assumptions to those changes in the matter-energy system known as chemical reactions. We will also use the kinetic-molecular model to make predictions about the effect of these reactions.

Two basic kinds of chemical reactions occur in living organisms: (1) the synthesis of simple molecules into complex molecules, and (2) the reverse, the separation of complex molecules into simpler molecules. The chemical synthesis reactions serve two purposes in organisms: (1) they build the giant molecules that make the structure of the organisms, and (2) they serve as a means of storing chemical energy. The reactions which separate complex molecules have the primary function of making the chemical energy stored in the molecule available for use by the organism. The energy is used to produce physical movement, to generate heat or light, and to synthesize other complex molecules.

We will use a set of very simple symbols as part of our model. The symbols represent molecules and atoms and will provide us with an easy way to look at changes in living matter-energy systems. For example, a synthesis reaction can be represented as shown in slide [#11]. Each square represents a molecule; the letters indicate different kinds of molecules; the arrow indicates the direction of change. The arrow can be read as "makes", or "becomes" or "forms". The symbol E_1 represents the particular amount of energy involved in the reaction. This very simple, compact representation of a reaction can be read: a molecule of substance A combines with a molecule of substance B to make a molecule of a new, more complex substance C when the energy E_1 is supplied. Substance A and B are called the *reactants* since they react to produce substance C. Substance C is called the *product* of this synthesis reaction. Synthesis reactions are those where two or more simple molecules combine to form a molecule which has more atoms than any one of the reactant molecules. In this example, energy is also described as a reactant.

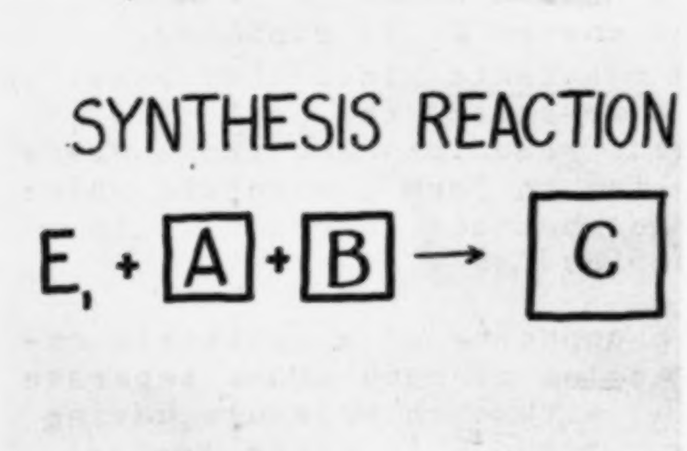
A *separation* reaction is the opposite of a synthesis reaction. One or more complex molecules of many atoms separate into two or more simpler molecules with each molecule having fewer atoms. This representation is shown in slide twelve [#12]. In this case substance C is the reactant and substance A and B and the energy are the products. While some synthesis reactions release energy, those that occur in living systems use energy as a reactant and store energy as chemical energy.

TURN TO SELF-CHECK 5

The assumptions of our matter-energy model can help us predict that a number of factors will affect chemical reactions. The first three assumptions deal with matter rather than energy. The first, all matter is made up of atoms and molecules, and these particles have weight, suggests that our reaction model should be read to mean that many particles of A and of B, having a given weight, react to form many molecules of C which weigh the same as A plus B. The synthesis of a single molecule of C is very unlikely because it would be very difficult to isolate a single molecule of A and a single molecule of B and then bring them together.

In our example, it is suggested that all of the atoms which are in molecules of A and B must either be found in molecules of C or in some remaining group. They are not "lost" during the change. Conversely, all of the atoms which compose the molecules of C were previously in some other arrangement; no atoms are "gained" during the reaction.

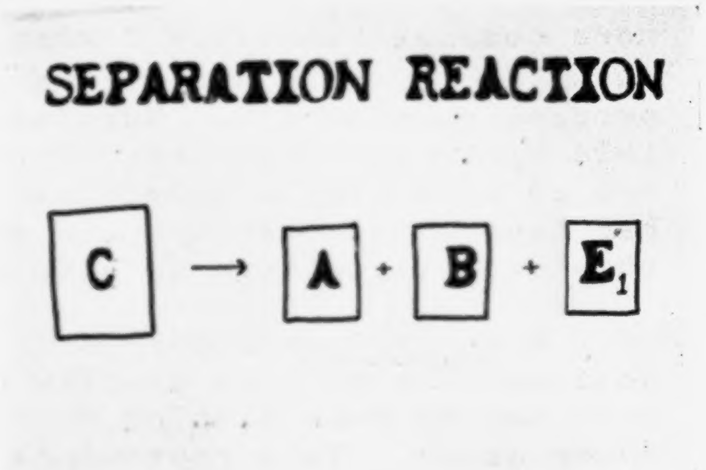
However, there is space between particles.[#13]. If a molecule of A and a molecule of B are to combine to make a new molecule, they must come together. How close molecules of A and B are to each other depends upon how many particles of each kind are in a given space. This factor is called the concentration of the substances. Concentrations can be changed by: (a) changing the number of particles in a certain space, (b) changing the space in which the particles are contained, or (c) some combination of the two. However, if the particles of B are packed close together, particles of A can only combine with the B's on the surface. Exposure to reaction depends upon the surface area; hidden particles under the surface cannot react.



SYNTHESIS REACTION

$E_1 + \boxed{A} + \boxed{B} \rightarrow \boxed{C}$

Slide 11



SEPARATION REACTION

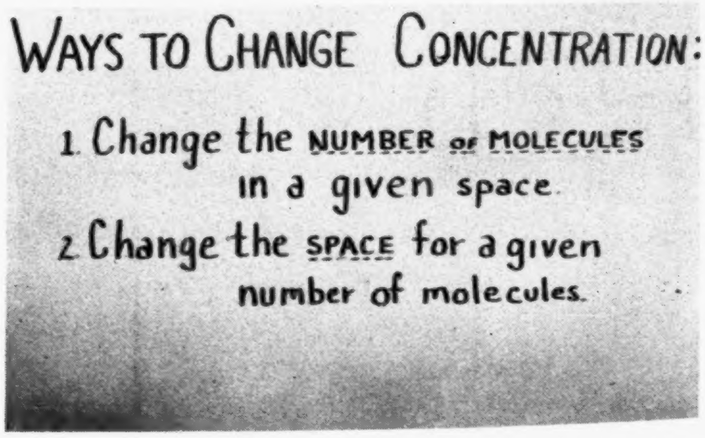
$\boxed{C} \rightarrow \boxed{A} + \boxed{B} + \boxed{E_1}$

Slide 12

TURN TO SELF-CHECK 6

Although particles can combine to form new molecules, the model does not suggest that every time a molecule of A collides with a molecule of B a reaction occurs. If this were true, we would not observe particles of A and B in the same space, we would only observe particles of C.

Our chemical reaction model explains this observation in the following way. Most molecules have only two areas where other molecules can be attached or bonded to them. Symbolically, this can be shown by extending "lines" or hooks from the "sides" of molecules. Remember, this is only symbolic representation since molecules and atoms are three dimensional. Thus, our representation of a chemical reaction can be pictured. [#14] Notice that the new molecule, C. has the capacity to react. At least two reactive places continue to exist no matter how many basic units become linked or bonded together.



WAYS TO CHANGE CONCENTRATION:

1. Change the NUMBER of MOLECULES in a given space.
2. Change the SPACE for a given number of molecules.

Slide 13

In order to chemically combine, molecules must not only collide with each other, they must collide in such a way that the reactive points come together. Only "head on" collisions bring about change; "side swipes" or "front-tail" collisions result in no change. Our model, then, suggests that the shape of the molecule and the position of the reactive points are important in determining if the reaction will occur.

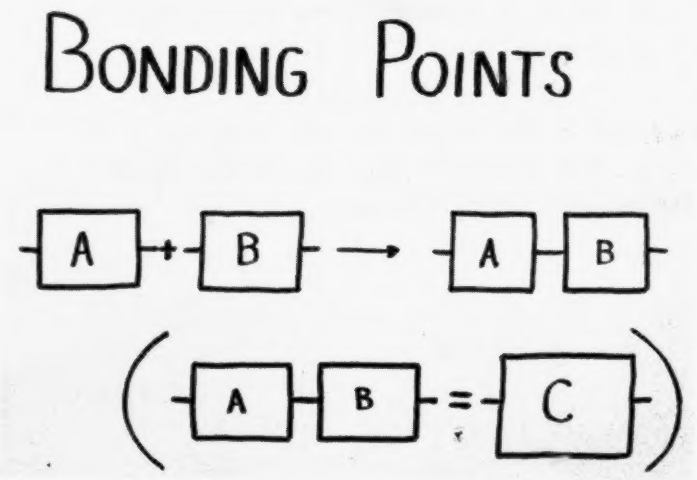
To summarize, we can predict a number of things from our chemical reaction model. It tells us that:

1. No atoms are gained or lost in a chemical reaction.

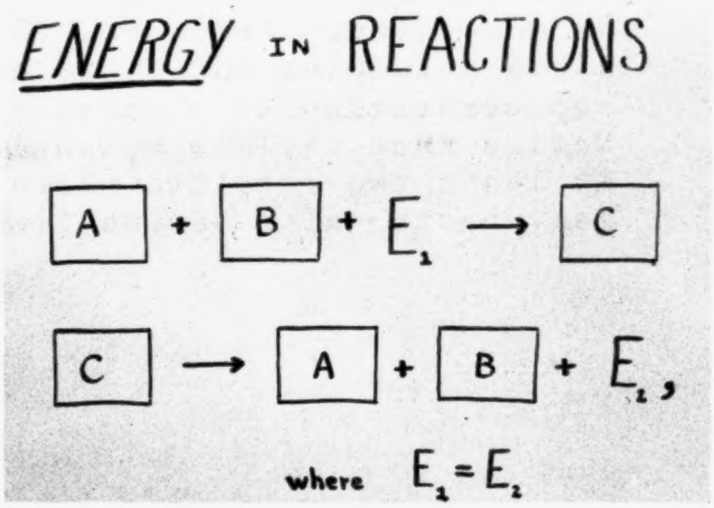
2. The concentration of reactants and the amount of available surface area can affect the rate of chemical change by determining the frequency of collisions.

3. Not all collisions will lead to reaction. The shape of the molecules and the position of the reactive points means that some collisions cannot produce reactions.

We still have not considered the fourth assumption of the kinetic-molecular model, the one dealing primarily with the energy of the system. As particles have two forms of energy, kinetic and chemical or potential, there are two suggestions for chemical reactions from this assumption. [#15]



Slide 14



Slide 15

We have noted that particles of A and B must collide in order for a reaction to occur, and that concentration and exposed surface area are two factors which affect the frequency of collisions. These collisions are the result of the constant, random motion of the particles. Molecules which are moving fast have more of a chance of striking another particle in a limited amount of time than do molecules which are moving slowly.

Kinetic energy determines the speed of the motion. Therefore, kinetic energy affects the frequency of collisions, and also the force of the collisions.

Temperature is a measure of the average kinetic energy of particles; an increase in kinetic energy is evident as a rise in temperature. Thus, heating substances can increase the chance of collision.

TURN TO SELF-CHECK 7

One more factor which affects chemical reactions can be predicted on the basis of our model of matter. Recalling that our model suggested that each molecule has a characteristic amount of chemical energy, a molecule of C would be expected to have a different amount of energy than either A or B. This energy can be found in the chemical bonds of the substance, C. The bonds represent the forces that hold a molecule of C together. It can be pictured as the junction of molecule A's reactive points with molecule B's reactive points, within the molecule C. When this bond is broken, the enrgy associated with it is released and molecules of A and B reappear. In our example, the absorption of the given amount of energy, E_1, means that C's chemical energy is greater than that of the chemical energies of A and B combined. If A and B were combined with a different amount of energy, say E_2, substance C would not be the product. Because each substance has a characteristic amount of energy, we could predict that energy in a synthesis reaction is equal to the energy in a separation reaction of the same molecule. [#15]. This prediction would be supported by observation. Energy, like atoms, is not "lost" or "gained" during a chemical reaction.

TURN TO SELF-CHECK 8

MATTER-ENERGY UNIT
Part III

WORKSHEET

ANSWER	QUESTION
	Self Check 5
Synthesis of complex molecules and separation of complex molecules into simpler molecules.	1. What are the two reactions that occur in living organisms?
Synthesis reactions build giant molecules and also store chemical energy.	2. What two purposes are served by synthesis reactions?
$A + B + E_1 \rightarrow C$	3. Use symbols to write a description of a synthesis reaction.
A and B are reactant materials and C is the product material.	4. In the reaction that you represented identify the reactant materials and the product materials.
	5. The following representations are for specific chemical reactions in which symbols for actual elements and compounds are used. (a) circle the products and underscore the reactants. (b) in the blank indicate whether the reaction is a synthesis or a separation reaction.
H_2 and O_2 are reactants (synthesis) H_2O and E_1 are products	$2\ H_2 + O_2 \rightarrow 2\ H_2O + E_1$ _____

ANSWER	QUESTION
C and H_2 plus E_2 are reactants (synthesis) CH_4 is a product	$C + 2 H_2 + E_2 \rightarrow CH_4 +$ ______
CO_2 and E_3 are reactants (separation) C and O_2 are products	$CO_2 + E_3 \rightarrow C \quad O_2$ ______
NH_3 and E_4 are reactants (separation) N_2 and H_2 are products	$2 NH_3 + E_4 \rightarrow N_2 + 3 H_2$ ______
It represents a single molecule made of one atom of nitrogen and three atoms of hydrogen.	6. What can be read from the symbol NH_3 ?
The element hydrogen is made of molecules containing two atoms per molecule.	7. What can be read from the symbol. H_2?
Because any observable amount of matter contains billions of molecules. It would also be very difficult to isolate a single molecule of each kind and then make sure they collided. It would be similar to tossing two bottles in the ocean at points several miles apart and then expecting them to come together.	8. Why should we read our symbolic representation of a reaction as involving many reactant molecules and producing many product molecules?

! STOP !

CONTINUE THE TAPE-SLIDE PRESENTATION

MATTER-ENERGY UNIT
III WORKSHEET

ANSWER	QUESTION
	Self-Check 6
	9. Are all the atoms accounted for in the following specific reactions?
Yes: There are two atoms of nitrogen and six atoms of hydrogen in the reactants and the same number in the products.	a. $N_2 + 3 H_2 \rightarrow 2 NH_3$ ____
No: There are two atoms of hydrogen and two atoms of oxygen in the reactant molecules, while the products contain two atoms of hydrogen but only one atom of oxygen. Actually a reaction would take place as follows: $2 H_2 + O_2 \rightarrow H_2O$	b. $H_2 + O_2 \rightarrow H_2O$ ____
It would imply that we had the power to make or destroy matter.	10. If we did not account for all atoms or groups of atoms in a reaction what would be implied?
	11. For the chemical reaction $A + B + E_1 \rightarrow C$ predict what would happen to the rate of reaction if:
a) the rate will speed up because more collisions can occur among molecules.	a) the volume of the reaction container is reduced to half size.
b) the rate will speed up because more collisions can occur among molecules.	b) the quantity of A is doubled while the volume of the container does not change.

! STOP !
CONTINUE THE TAPE-SLIDE PRESENTATION

MATTER-ENERGY UNIT
III WORKSHEET

ANSWER	QUESTION
	Self Check 7
They cannot make contact with other particles, and contact is necessary for a reaction to occur.	12. Why is it impossible for particles hidden under a solid surface to react?
The reactive points do not meet in all collisions. They have to meet for reaction to occur.	13. Why is it that some collisions between reactants do not produce reaction?
Head on collisions lead to the formation of new molecules.	14. What kinds of collisions produce reaction?
Side swipes and front tail collisions do not lead to formation of new molecules.	15. What kinds of collisions do not produce reactions?
The kinetic energy or speed of the particles increases, as the temperature rises.	16. What will happen to the kinetic energy of molecules in a container if the temperature rises?
The greater speed created by increased kinetic energy will increase the number of collisions.	17. What effect will increased kinetic energy have on the collisions of particles in a container?

ANSWER	QUESTION
The reaction rate will speed up if the temperature is increased.	18. What will happen to the reaction rate of $A + B \rightarrow C + E_1$ if the temperature of A and B is increased?
First, it is energy that becomes evident when bond changes occur during chemical reaction. Second, it can be converted to kinetic energy during reaction. Third, it is the measurable energy that must enter or leave as reaction occurs.	19. What is chemical energy?

! STOP !

CONTINUE THE TAPE-SLIDE PRESENTATION

	Self Check 8
Choice B is the correct answer.	20. For each reaction choose the best predicted products or reactants. If $A + B + E_1 \rightarrow C$ Then ________ $\rightarrow A + B + E_1$ a. $C + E_2$, where $E_1 \neq E_2$ b. C c. B

MATTER-ENERGY UNIT
III WORKSHEET

ANSWER	QUESTION
Choice B is the best answer.	21. If $M + N \rightarrow P + E_1$ Then $P + E_1 \rightarrow$ a. $M + N + E_2$ b. $M + N$ c. O

! STOP !

Matter-Energy Unit
Quiz 1

DO NOT WRITE ON THIS PAPER: DARKEN THE APPROPRIATE LETTER OR WRITE YOUR ANSWER ON THE ANSWER SHEET. DO NOT GIVE MORE THAN ONE ANSWER FOR EACH QUESTION.

1. The form of matter which best keeps its shape is a

   a. solid b. liquid c. gas d. mixture e. gel

2. What is one of the properties of liquids that would change if the molecules were further apart? (More than one possible answer.)

   a. fluidity b. shape c. compressibility d. weight

3. Gels, when at low temperatures, have properties most similar to

   a. solids b. liquids c. gases d. mixtures

4. The simplest kind of matter which cannot be divided into simpler substances is a(n)

   a. solid b. molecule c. compound d. mixture
   e. element

5. The kind of matter which does not have properties of its own, but has the properties of the substances of which it is composed is a(n)

   a. compound b. molecule c. mixture d. gel e. solid

6. The smallestparticle of a compound which still has the properties of the compound is called a(n)

   a. molecule b. atom c. mixture d. gel e. solid

7. The smallest particle of an element which still has the properties of the element is called a(n)

   a. compound b. atom c. molecule d. solid e. mixture

8. Compressing a gas (but maintaining a gaseous form) would change the

   a. concentration b. number of molecules c. surface area
   d. weight

9. The form of matter which would have the greatest surface area for a given mass is a

   a. solid b. liquid c. gel d. gas

10. At what temperature are molecules most likely to have the greatest frequency of reaction-producing collisions?

a. 0° C b. 10° C c. 50° C d. 100° C

11. In a reaction $E_1 + A + B \rightarrow C$, C has

a. more chemical energy than A b. more chemical energy than B c. more chemical energy than A + B d. all three previous answers

12. If $E_1 + A + B \rightarrow C$, then $E_2 + A + B \rightarrow$ ______

a. C b. a molecule other than C c. E_1 d. $A + E_1$

13. When the chemical energy of foods or fuels is being digested or burned, the energy can be classed as

a. potential b. kinetic c. not existent

14. The motion of pollen grains first seen by Brown suggested the form of energy known as

a. potential b. kinetic c. chemical

15. Which one of the following reactions is not possible?

a. $CH_4 + O_2 \rightarrow CO_2 + H_2O$ b. $CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O$

c. $2\ H_2 + O_2 \rightarrow 2\ H_2O$ d. $4\ H_2 + 2\ O_2 \rightarrow 4\ H_2O$

16. For each symbol below, tell how many kinds of atoms are shown and how many atoms altogether are shown: (Use ANSWER SHEET)

	Number of Kinds of Atoms	Total number of atoms
NH_3		
C_2H_5OH		
NH_4OH		
H_2O		

17. For each symbol below identify the element represented. (Use ANSWER SHEET)

C = ______ H = ______ O = ______ N = ______

18. For each case below indicate the affect of the addition (+) or subtraction (-) of heat on the substances shown by checking ONE of the two columns.

	Particles move closer together	OR	Particles move further apart
a. water + heat	____________		____________
b. steam - heat	____________		____________
c. gelatin - heat	____________		____________

19. List two distinct ways in which an organism uses the energy released from molecules. (Use ANSWER SHEET)

For questions 20 - 23, use the following representation:

$$E_1 + A + B \rightarrow C$$

20. This reaction is a ___ reaction.

a. energizing b. synthesis c. separation d. particulate

21. The "C" would be described as a

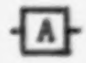
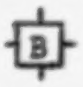
a. reactant atom b. reactant molecule c. product atom
d. product molecule

22. The "E" represents

a. a reactant molecule b. amount of energy necessary for reaction to occur c. energy released when "C" is made
d. a product molecule

23. The grinding of substance "B" would change the

a. concentration b. volume c. surface area d. weight

24. Of two molecules,  and  , which is the most likely to have a higher rate of reaction-producing collisions?

a. A b. B

25. Describe a chemical bond. (Use ANSWER SHEET)

NARRATIVE FOR LARGE GROUP, SMALL GROUP,
OR TAPED PRESENTATION

MATTER-ENERGY UNIT
PART IV: MOLECULES OF LIVING ORGANISMS

The molecules found in living organisms, the energy associated with these molecules, and the changes in the matter-energy system of life are generally more complex than those found in the non-living world. Their complexity is the result of the large number of atoms involved in the molecules and the arrangement of the atoms in space. A molecule of table sugar, found in sugar cane, consists of 45 atoms. It is one of the smallest molecules found in living organisms. Hemoglobin, the particle responsible for the red color of your blood, has 9,512 atoms. The molecular formula for hemoglobin is:

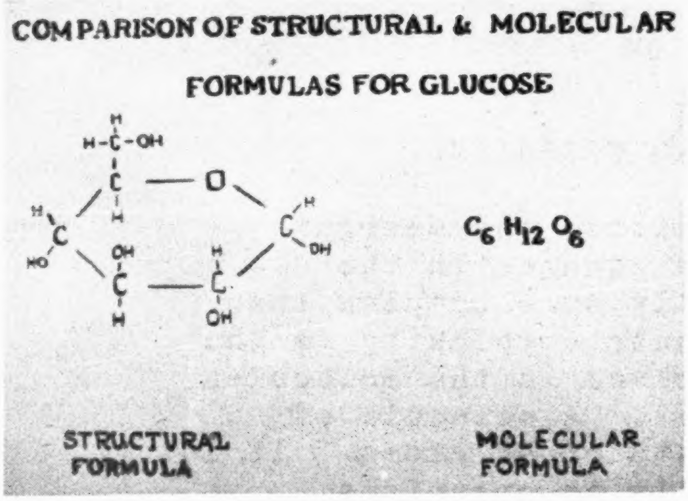
$$C_{3032}\ H_{4816}\ O_{872}\ N_{780}\ S_8\ Fe_4$$

Another source of complexity is the arrangement of atoms in molecules. Four molecules, all with the same number and kind of atoms, $C_6\ H_{12}\ O_6$, have different properties because of the arrangement of the atoms in relation to each other.

Molecular formulas such as H_2O show the number and kind of atoms in molecules. They are not adequate when considering the complex molecules of living organisms since the spatial arrangement of the atoms determines the nature of the molecule. For this reason, structural formulas showing the spatial arrangement of atoms are used. A comparison of molecular and structural formulas is shown in slide [#16]. The structural formula in slide 16 represents glucose. As in molecular formulas, the letters in a structural formula represent atoms of elements and the lines represent chemical bonds. While the structural formula does show the ring-like structure of a molecule, a printed structural formula has only two dimensions: up and down and right and left. Molecules are three dimensional. The third dimension not shown on paper is the front to back relationship.

These complex molecules were called organic molecules initially because they were thought to exist only in living matter. Today the term organic refers to all molecules which contain carbon. Organic substances found in living cells, even though complex and different, have enough properties in common to be grouped into distinct categories. The major categories of living matter, based on structure, composition, and function are carbohydrates, fats, and protein. [#17] Other categories which will be considered as special cases of the three major groups are enzymes, nucleic acids, and hormones.

~~TURN TO SELF-CHECK 9~~



COMPARISON OF STRUCTURAL & MOLECULAR FORMULAS FOR GLUCOSE

$C_6H_{12}O_6$

STRUCTURAL FORMULA

MOLECULAR FORMULA

Slide 16

Composition of Living Systems

(1) Proteins

(2) Carbohydrates

(3) Fats

Slide 17

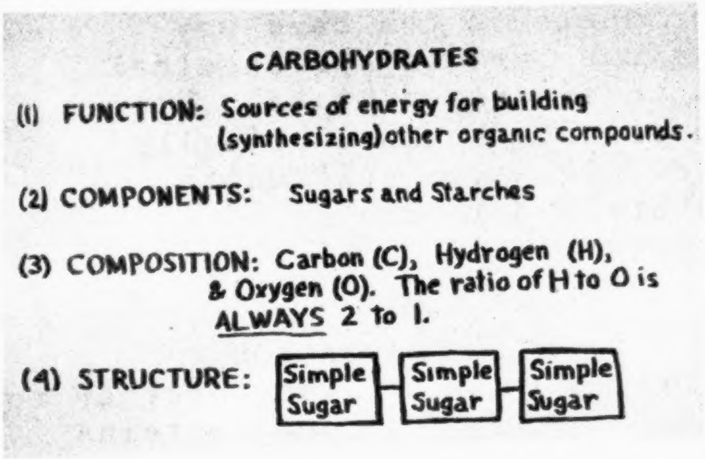
Organisms use carbohydrates directly as building materials for synthesizing other organic compounds. They are also used as sources of energy by both plants and animals. Carbohydrates are composed entirely of carbon, hydrogen, and oxygen. Carbohydrate molecules can be identified by the fact that they always contain exactly twice as many atoms of hydrogen as of oxygen--the same ratio as in water. Common examples of carbohydrates are sugars and starches.

Molecules of glucose, a simple sugar, can link together at their two reactive points to make longer units. [18]

Common sugar is a two glucose chain. Other carbohydrates may contain three or more glucose units per molecule. Starch is a carbohydrate formed by many units of simple sugars like glucose. Starch is insoluble in water. It serves as a form of food storage in plants and thus is a warehouse of chemical energy.

The term fat, like carbohydrate, indicates a group of related compounds rather than one specific compound. [#19]. Fats are also composed of carbon, hydrogen, and oxygen. However, the ratio of hydrogen to oxygen is much greater than the two to one ratio of carbohydrates. There are many more hydrogen atoms for each oxygen atom. For instance, the molecular formula of stearin, a fat, is $C_{57}H_{110}O_6$. This high ratio of hydrogen to oxygen is a distinguishing characteristic of fats. Some common examples of fats are butter, solid fat on meat, and the oils of cotton seeds, olives, and peanuts.

Just as carbohydrates are chains of smaller components linked at their reactive points, fats also are made up of linked components. The two major components of fats are known as glycerol and fatty acids. A molecule of fat has a ratio of one molecule of glycerol to three molecules of fatty acid. The three fatty acids of a given fat molecule may be alike or different.



CARBOHYDRATES

(1) FUNCTION: Sources of energy for building (synthesizing) other organic compounds.

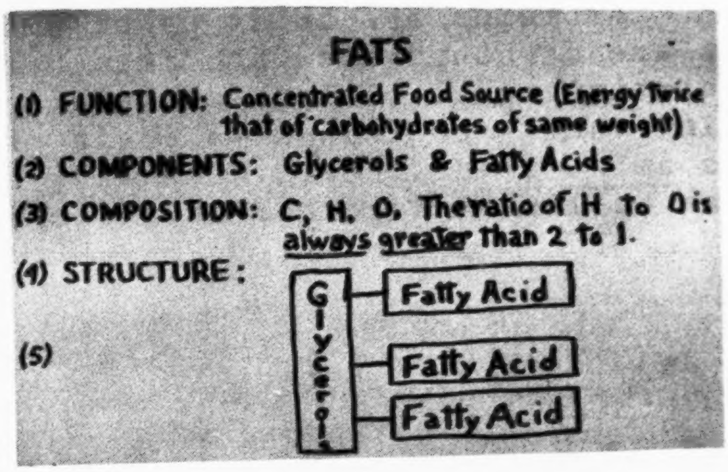
(2) COMPONENTS: Sugars and Starches

(3) COMPOSITION: Carbon (C), Hydrogen (H), & Oxygen (O). The ratio of H to O is ALWAYS 2 to 1.

(4) STRUCTURE:

Simple Sugar
Simple Sugar
Simple Sugar

Slide 18



FATS

(1) FUNCTION: Concentrated Food Source (Energy Twice that of carbohydrates of same weight)

(2) COMPONENTS: Glycerols & Fatty Acids

(3) COMPOSITION: C, H, O, The ratio of H To O is always greater than 2 To 1.

(4) STRUCTURE:

(5)

Glycerol
Fatty Acid
Fatty Acid
Fatty Acid

Slide 19

Fats, like starch, are insoluble in water. They are often stored on both plants and animals. Fats represent a highly concentrated form of energy storage. The breakdown of fats releases more than twice as much energy as an equal weight of carbohydrates. Fats also serve as a source of building units for the synthesis of other kinds of molecules.

TURN TO SELF-CHECK 10

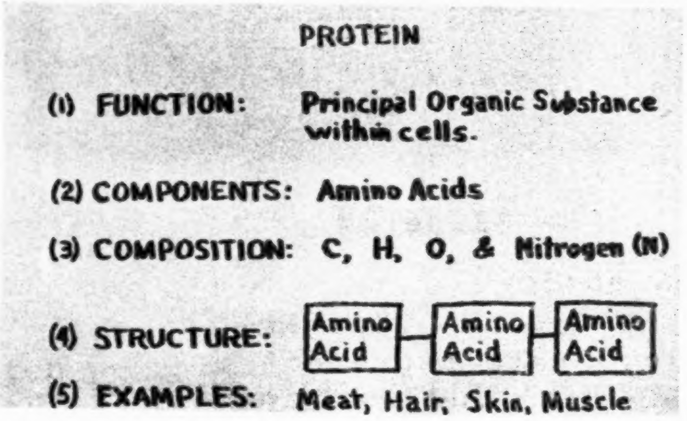
In 1838, A Dutch chemist, Guard Mulder, wrote,

> There is present in plants and in animals a substance which...is without doubt the most important of all known substances in living matter, and, without it, life would be impossible on our planet. This material has been named "protein".

Proteins are the most important groups of molecules found in living matter. [#20]. As the principal organic substance within cells, they represent nearly one-half of the matter of the human body. For example, proteins make up most of the skin, muscles, bones, hair, and nails. Proteins have a special importance. They are the components of enzymes, hormones, and the hereditary material of cells. The importance of these substances in directing and controlling the body's activities will be explained later.

All proteins are composed of carbon, hydrogen, oxygen, and nitrogen. It is the nitrogen that is the special mark of a protein. It is found only in proteins, in the components of proteins, or in compounds containing proteins. Proteins are also the largest molecules in terms of number of atoms and total weight of molecules. Hemoglobin, the blood protein mentioned before as having 9,512 atoms, is only a medium size molecule of protein.

Proteins are built up of smaller units in the same way as are carbohydrates and fats. If we use part of our chemical reaction model of linked basic units to examine a protein, we find that a protein is a chain of substances known chemically as amino acids. [#21]. As many as 100,000 amino acid units can be linked together in a single protein molecule.


PROTEIN

(1) FUNCTION: Principal Organic Substance within cells.

(2) COMPONENTS: Amino Acids

(3) COMPOSITION: C, H, O, & Nitrogen (N)

(4) STRUCTURE: Amino Acid — Amino Acid — Amino Acid

(5) EXAMPLES: Meat, Hair, Skin, Muscle

Slide 20

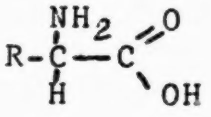
AMINO ACIDS

(1) Function: link together to form proteins

(2) Components: Amino group (NH_2)
Acid group (COOH)
Radical group (R)

(3) Composition: C, H, O, N

(4) Structure:



$$R-\underset{H}{\overset{NH_2}{C}}-C\overset{\nearrow O}{\underset{\searrow OH}{}}$$

Slide 21

Amino acids are organic compounds characterized by having both an amino group, $-NH_2$, and an acid group containing a double bonded oxygen, COOH, bonded to other groups of atoms. Slide #21 shows a structural formula for an amino acid. Note that the double bond in the acid group is shown by drawing two lines between the carbon and oxygen. This structural formula indicates that amino acids differ according to the group represented by the letter R. The R stands for any one of many different carbon chains. The total number of different amino acids is not known. Twenty-four are reasonably well established as distinct forms present in living organisms.

Part of the complexity and variety of proteins comes from the many possible sequences of the amino acids that can be put together. Protein molecules can consist of ten thousand to one hundred thousand amino acid groups. With more than twenty different amino acids to be used in the synthesis of these molecules, an astronomical number of different proteins are possible.

TURN TO SELF-CHECK 11

Our kinetic-molecular model suggests that molecules occupy space. We pointed out that structural formulas on printed paper do not show the spatial third dimension of molecules. These ideas become very important in examining proteins. Although we have represented proteins as chains of amino acids, most proteins are not long fibrous molecules. The chains can coil so that the molecules are shaped like large clumps of solid in small amounts of liquid. The coils are close enough so that weak bonds can link sections of the chain together. [#22]

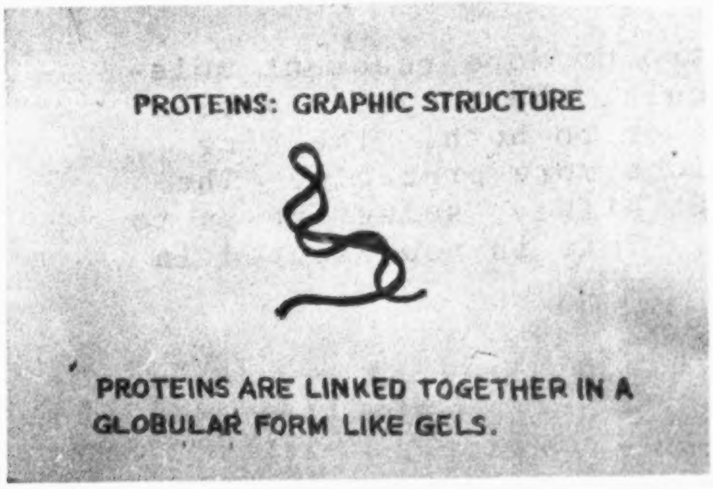
Relatively small disturbances of protein molecules, such as low heat or slight changes in the acidity of the surroundings, can either create more linkages or break existing linkages. Recall from the motion picture of the first day the gelatin solution in film clip 20. Remember when the gelatin was warm...then after cooling? What about the change in the eggs when heated? These changes were due to changed, or denatured, proteins. Blood banks take special care of the protein portions of blood to prevent such denaturing during storage of blood before transfusions.

The following statements are examples of the behavior of proteins. These behaviors remain to be explained:

(1) The average protein must be boiled for 24 hours in a highly acidic solution to be completely separated into its component amino acids. The human body does the same thing during digestion in four hours or less, without high temperatures or strong acids.

(2) When one hundred cubic centimeters are filled with a mixture of two organic substances, at room temperature, there are 16 million billion billion billion collisions per second between the unlike molecules. Yet fewer than one out of every billion billion collisions result in a chemical reaction.

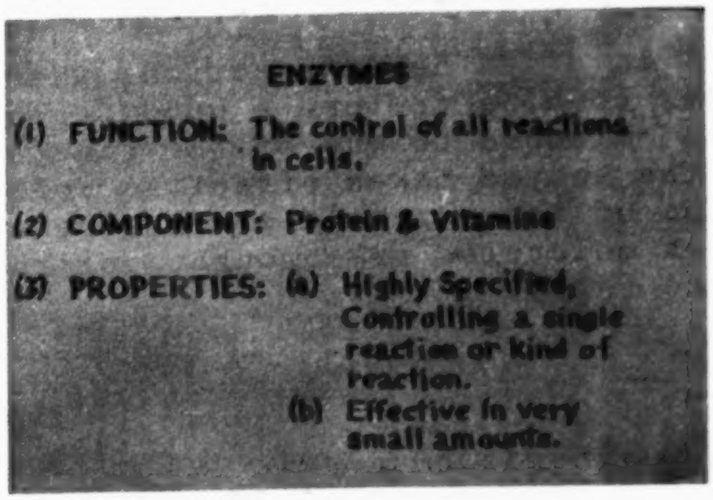
Chemical reactions in living organisms involve special changes in the matter-energy system. The substances which control all reactions in cells by accelerating reactions are known as enzymes. They are special proteins that enable very slow reactions to occur at useful rates at ordinary temperatures. Enzymes turn leaves red and yellow in the Fall; they make the freshly cut surface of an apple or potato turn brown.



PROTEINS: GRAPHIC STRUCTURE

PROTEINS ARE LINKED TOGETHER IN A GLOBULAR FORM LIKE GELS.

Slide 22



ENZYMES

(1) FUNCTION: The control of all reactions in cells.

(2) COMPONENT: Protein & Vitamins

(3) PROPERTIES: (a) Highly Specified, Controlling a single reaction or kind of reaction.
(b) Effective in very small amounts.

Slide 23

There are several thousand kinds of enzymes in every living cell. Yet there may be as few as 50 molecules of a given enzyme present in a cell. These facts lead to two of the special properties of enzymes that we will attempt to explain with our model. They are:

(1) Enzymes are highly specific, controlling a single reaction or kind of reaction, and

(2) Very small amounts of enzymes are effective.

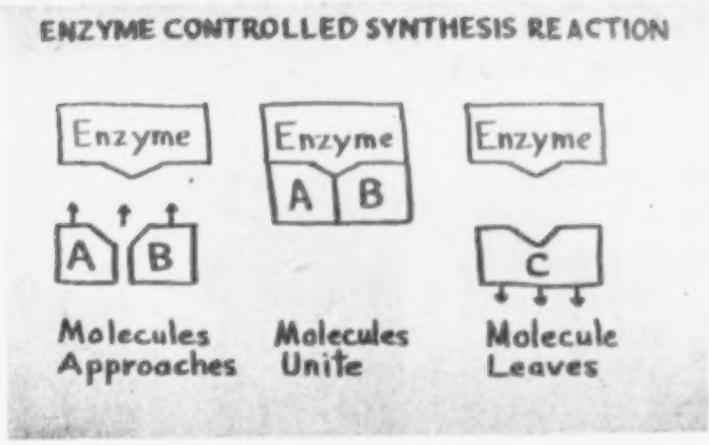
The major portion of each enzyme molecule is a protein unit. The non-protein part of an enzyme is composed of organic units called vitamins. Vitamins are also essential to the activity of the enzyme. This is one reason why vitamins are so necessary in our diet.

TURN TO SELF-CHECK 12

Enzymes have highly complex molecular compositions and shapes. When we examined chemical reactions, we found that the shape of the molecules and the position of the reactive points affect chemical reactions. Considering these ideas together, we may find an explanation for the specific action of enzymes in chemical reactions.

Enzyme molecules are generally very large in comparison to the reacting particles such that collisions between the enzyme and the reactants are more probable than collisions between the reactants themselves. The complex twisted shape of the enzyme's surface limits the number and kind of molecules which can temporarily link to the enzyme. They must have a shape that fits the enzyme. Work completed at the University of Chicago by E. S. Barron indicates that a difference in shape of about one billionth of an inch or thirty-five thousand millionths of a centimeter is enough to prevent the fit of a reactant molecule on an enzyme.

In a synthesis reaction, where two or more reactant molecules combine to form a product molecule, the enzyme may become attached to one of the reactants or to both. The size of the enzyme makes effective collisions more probable. The shape of the enzyme's surface makes it highly selective as to which molecules are brought together. This is represented in slide [#23].



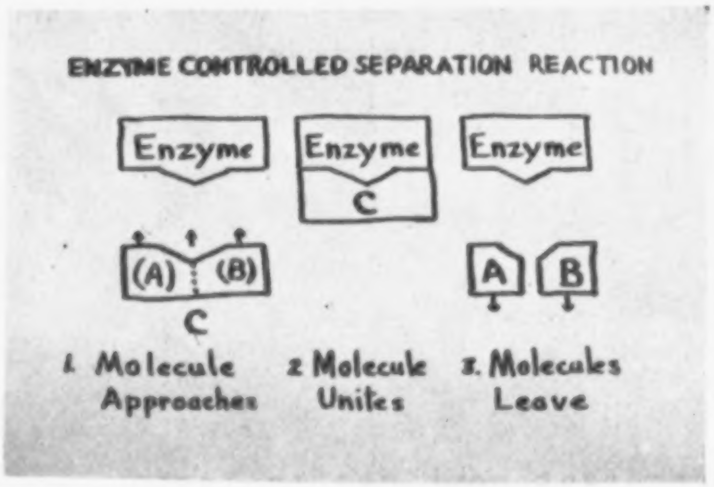
Slide 24

In these reactions, the enzyme-reactant combination lasts less than one 85,000th of a second. The enzyme is not altered. It can repeatedly combine with reactant molecules. Thus a small number of enzyme molecules could affect as many as five million reactant molecules each minute. In fact, a single molecule of the enzyme that aids in separating hydrogen peroxide into water and oxygen, and creates the white foam you witnessed in film clip #2 can transform more than five million peroxide molecules a minute. Other enzymes transform 1,000 to more than 500,000 molecules in a minute.

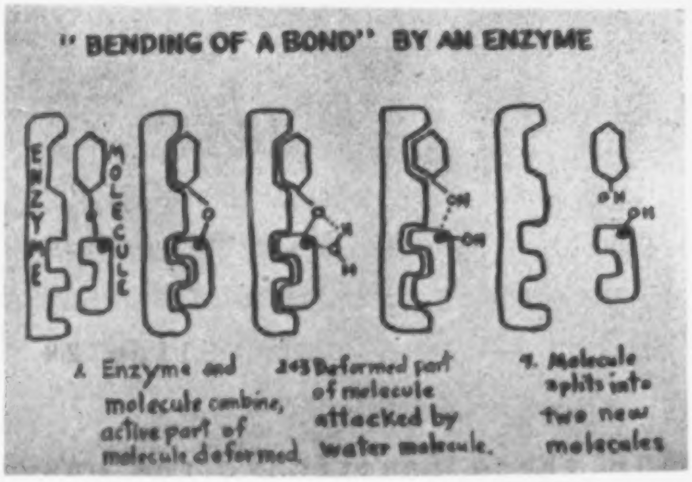
Basically then, an enzyme functions in a synthesis reaction by bringing specific reactant molecules together in a way that encourages reaction. The form of the enzyme affects this function.

Enzymes also control separation reactions. In a separation reaction, a single reactant molecule separates into component products. Something more than the shape of the enzyme must be involved to explain the breaking of the chemical bonds, or energy links, between the molecules.

Our chemical reaction model suggested that: (1) the relative position of reactive points on molecules could affect their ability to form chemical bonds, and (2) each molecule has a characteristic amount of energy. Any change in the energy will result in changes in the molecule. Let us apply these two ideas to the action of enzymes in separation reactions. If the enzyme is to affect the reactant molecule, it must combine with it. The shape of the enzyme limits it to combining only with those molecules which fit it. This makes enzymes highly specific. The combination, again, is short-lived. What happens in that brief period? Slide [#25] shows a separation reaction. The portion of molecule C to which the enzyme attaches itself is the area of the chemical bond between components A and B. What is not yet known is whether the mere physical presence of the enzyme molecule is sufficient to stretch or bend the energy link until it breaks, or whether the enzyme molecule temporarily adds or subtracts energy from the link to change it. It is known that, as the enzyme molecule is the same after the reaction as before, any energy exchange is temporary and equal. A representation of the bending of a bond by an enzyme to bring about separation may be represented in slide [#26].


ENZYME CONTROLLED SEPARATION REACTION
Enzyme
Enzyme
C
Enzyme
(A)
(B)
C
A
B
1. Molecule Approaches
2. Molecule Unites
3. Molecules Leave

Slide 25


" BENDING OF A BOND" BY AN ENZYME
ENZYME
MOLECULE
OH
OH
OH
OH
H
1. Enzyme and molecule combine, active part of molecule deformed.
2+3 Deformed part of molecule attacked by water molecule.
4. Molecule splits into two new molecules

Slide 26

From this discussion and from laboratory observation, we can summarize the general properties of enzymes and their reactions:

(1) Enzymes accelerate the rate of chemical reactions in living organisms.

(2) The reactions may be either the synthesis or separation of substances.

(3) Enzymes are not consumed during these reactions and therefore are effective in small quantities.

(4) Enzymes are specific. Contrasted to heat which affects all reactions, enzymes affect one molecule or type of bond.

(5) The speed of enzyme activity is influenced by:

   a. The concentration of enzymes.
   b. The concentration of reactive substances.
   c. The temperature.

TURN TO SELF-CHECK 13.

WHEN YOU HAVE FINISHED THE SELF-CHECK, REVIEW THE MATERIAL IN PART IV. THEN PARTICIPATE IN A SMALL GROUP DISCUSSION.

MATTER-ENERGY UNIT
PART IV

WORKSHEET

ANSWER	QUESTION
	Self check 9
The large number of atoms in the molecules and the way the atoms are arranged produces the complexity of life molecules.	1. What two things contribute to the complexity of the molecules that form living matter?
Hemoglobin contains over 200 times as many atoms per molecule as sugar.	2. How does hemoglobin compare with table sugar in number of molecules?
Molecular formulas only show the number and kind of atoms in molecules and nothing about how they are arranged. (Reconsider question 1.)	3. Why are molecular formulas inadequate for showing the complexity of organic molecules?
They do show how the molecules are arranged and linked together.	4. What is the advantage of structural formulas for molecules?
A few of the things that can be noted are: (1) seven of the hydrogen atoms are bonded to carbon atoms, (2) Five of the hydrogen atoms are bonded to oxygen atoms, (3) one of the oxygen atoms is bonded between two carbons and (4) five of the carbon atoms plus one oxygen atom are bonded to form a hexagon.	5. From the slide show the structural formula for glucose, what can you tell about the way the carbon atoms, oxygen atoms, and hydrogen atoms are assembled.

MATTER-ENERGY UNIT
IV WORKSHEET

ANSWER	QUESTION
The categories are based on structure (how atoms are arranged in molecules), composition (what atoms are in the molecules, and the function performed by the molecules as parts of living organisms.	6. The categories for grouping organic substances are based on what factors?
They are carbohydrate, fats and proteins.	7. What are the three major categories for life substances?

! STOP !

CONTINUE THE TAPE-SLIDE PRESENTATION

	Self Check 10
They are made of carbon, hydrogen and oxygen. They contain two atoms of hydrogen for each one of oxygen.	8. What composition is characteristic of carbohydrates?
Organisms use carbohydrates as building or structural material, in the synthesis of other compounds and as a source of energy.	9. What three uses do organisms make of carbohydrates?
It can be a unit in a synthesis reaction. Glucose + Glucose → Glucose—Glucose	10. How is a sugar like glucose built into more complex molecules?

MATTER-ENERGY UNIT
IV WORKSHEET

ANSWER	QUESTION
They, like carbohydrates, are made of carbon, hydrogen, and oxygen, but with many more hydrogen atoms per oxygen atom.	11. What is the composition of fats?
One of them is a substance called glycerol, the other is a category made of substances called fatty acids.	12. Fats contain two kinds of building units; what are they?
Since water is a part of all living organisms, soluble substances would be difficult to store.	13. Both fats and starches are insoluble in water. Why would this property be a helpful characteristic for a substance that is to be stored in a living organism?
Fats supply twice as much energy as carbohydrates.	14. How much energy is stored in fats compared to carbohydrates?
Refer to question 11; they contain many more hydrogen atoms per oxygen atom than do carbohydrates.	15. Fats contain more energy than carbohydrates; what else do they contain in greater amount than carbohydrates?

! STOP !
CONTINUE THE TAPE-SLIDE PRESENTATION

MATTER-ENERGY UNIT
IV WORKSHEET

ANSWER	QUESTION
	Self Check 11
They are components of enzymes, hormones and hereditary material which have a part in directing and controlling life activities.	16. What are some of the reasons why protein is the most important category of life materials?
Proteins contain atoms of carbon, hydrogen, oxygen and nitrogen.	17. What elements are found in proteins?
Nitrogen is contained in proteins where it is not present in carbohydrates and fats.	18. What elements make proteins distinctive as life substances?
Proteins are the largest molecules in terms of numbers of atoms per molecule and total weight per molecule.	19. What else makes proteins distinctive among life substances?
Proteins are synthesized from amino acids.	20. What are the smaller units of which proteins are built?
amino acid + amino acid → (amino acid)-(amino acid)	21. Use the chemical reaction model to write a description for the synthesis of a protein.
An amino group, $-NH_2$; an acid group, $-COOH$; and R^- group made of variable numbers of carbon and hydrogen.	22. What subgroups are found in each amino acid?

MATTER-ENERGY UNIT
IV WORKSHEET

ANSWER	QUESTION
	23. Make complete amino acids of the following R^- groups.
The 24 known amino acids can be put together in many different sequences with thousands of units in a single molecule. A change in one amino acid in a large molecule makes a new kind of molecule. Many such changes are possible.	24. Why is there such variety and complexity among proteins?

! S T O P !

CONTINUE THE TAPE-SLIDE PRESENTATION

	Self check 12
The protein units coil rather than forming chains as one might think from looking at a two dimensional representation on paper.	25. Why is it important to picture proteins as three dimensionsal?

MATTER-ENERGY UNIT
IV WORKSHEET

ANSWER	QUESTION
Both heat or acidity tend to break some of the bonds between units in the molecules of proteins and lead to new linkages and thus new substances.	26. What does heat or acidity do to proteins?
In living systems they occur fairly quickly; outside of a life system they occur much more slowly.	27. What is the difference between protein separation into amino acids in a living system and outside a living system?
Enzymes are a special group of proteins that speed life reactions.	28. What special substances enable life reactions to occur more rapidly?
They are very specific in the reaction that they speed up and they are effective in very small amounts.	29. What two special properties do enzymes have?
Enzymes contain a protein unit and a vitamin unit.	30. What sub units go together to make enzymes?

! STOP !

CONTINUE THE TAPE-SLIDE PRESENTATION

MATTER-ENERGY UNIT
IV WORKSHEET

ANSWER	QUESTION
	Self check 13
The molecules of reactants must match the surface of the enzyme in order for the enzyme to speed the reaction.	31. **Why is the shape of the surface of an enzyme important to its function?**
Reactant molecules can be joined in about 1/85,000 of a second, so one enzyme molecule is not tied up with any pair of molecules for very long.	32. **Why can a very few enzyme molecules cause a great amount of reaction?**
Compare what you have drawn with slide [#9] of Part IV.	33. **Make a drawing of a symbolic representation of the way an enzyme functions.**
It brings reactant molecules together in such a way that they can be bonded together.	34. **In summary, an enzyme performs what kind of service in a synthesis reaction?**
Concentration and temperature (the amount of kinetic energy) of the molecules affects the reaction so as to produce separation and synthesis.	35. **What conditions contribute to whether an enzyme helps to synthesize large molecules or separate them into smaller molecules.**

ANSWER	QUESTION
The shape of the molecules must fit the enzyme surface for the enzyme to be useful to the reaction.	36. Why are enzymes so specific? Why do they aid the reaction of only certain molecules?
It either stretches or bends it or gives enough energy to the two molecules that they push apart.	37. What does the enzyme seem to do to the bond between two molecules to cause it to separate?
No. They are not altered by reaction. This is one reason why a few enzyme molecules can help speed up the reaction of many molecules.	38. Are enzymes changed as a result of their involvement in reaction?
(1) Enzymes accelerate reactions in living systems. (2) Enzymes can speed both synthesis and separation reactions. (3) Enzymes can be used over and over again since they are not changed by the reaction. (4) Enzymes are very specific as to the molecules that can fit on them and thus be affected by the enzymes. (5) Enzyme activity is influenced by concentration of enzyme, concentration of reactants and by temperature.	39. As a summary, list the general properties of enzymes.

! STOP !

Biology 1 Name ____________________
Laboratory Introduction to Part IV Period _____

After developing the models for matter and energy (Part II) and chemical reactions (Part III), the next two sections will consider the molecules of living organisms and the chemical reactions that produce energy in living organisms.

Before beginning the tape slide presentation for molecules of living organisms (Part IV), you will do a laboratory exercise that will introduce the following types of molecules found in living organisms: starches, sugars, proteins, fats, and enzymes. The laboratory will only involve a recognition of these molecules that will be described later.

The laboratory consists of two parts:

Part 1 - Tests for Starch, Sugar, Protein, and Fat

1. Observe slides [A - H] and fill out the chart.
2. Have your teacher check the chart for completeness.

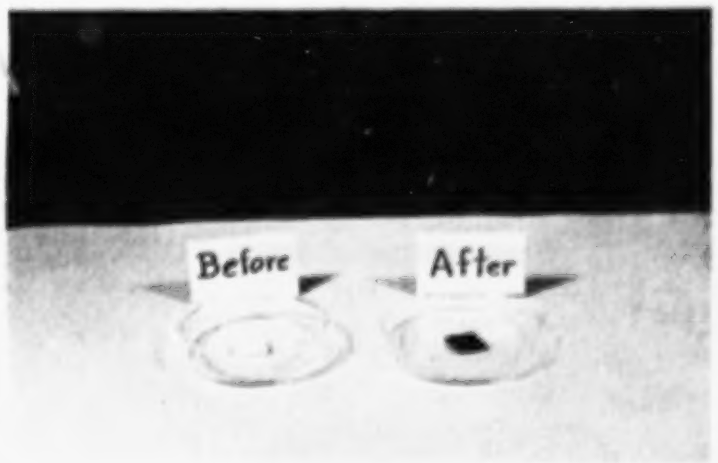
Part 2 - Enzymes in Living Materials

1. Complete the laboratory investigation in class.
2. Complete the data sheet and discussion page and hand in the next day.

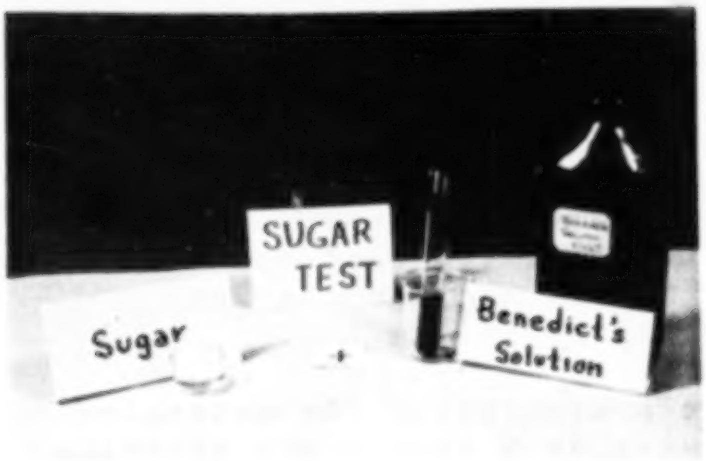
After completing the laboratory, begin the tape slide presentation for Part IV.

STARCH
TEST
Starch
Add one
drop of
Iodine

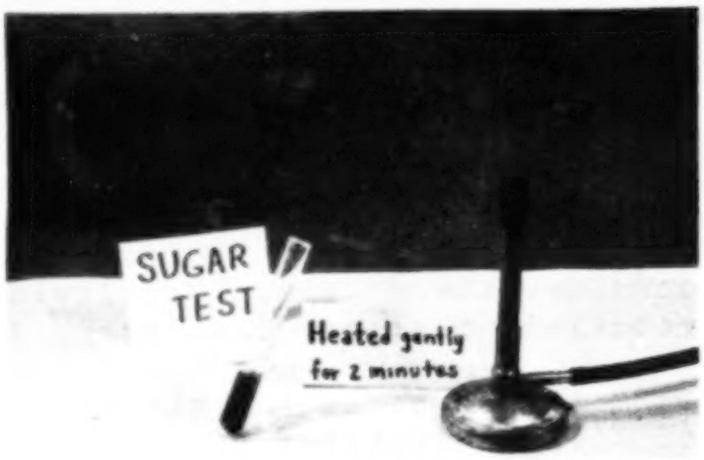
Slide A



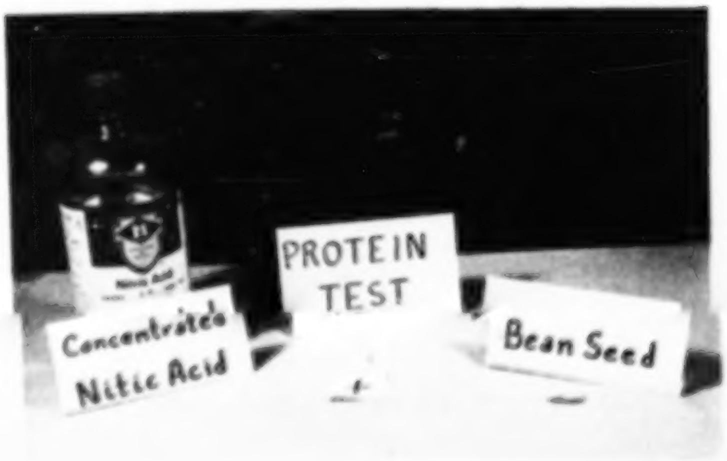
Slide B


SUGAR TEST
Sugar
+
Benedict's Solution

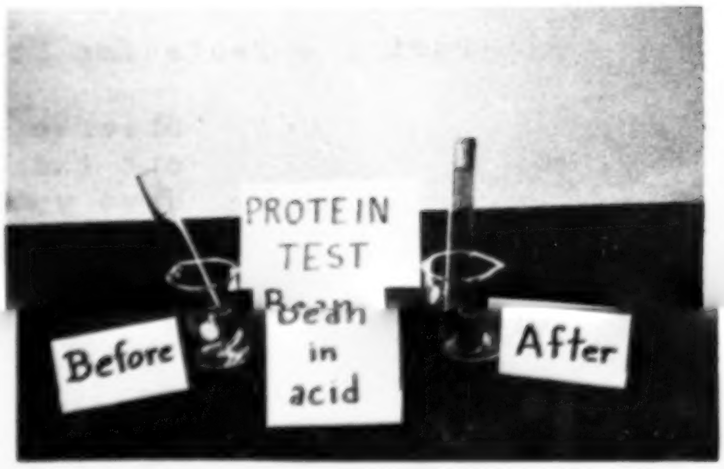
Slide C


SUGAR TEST
Heated gently for 2 minutes

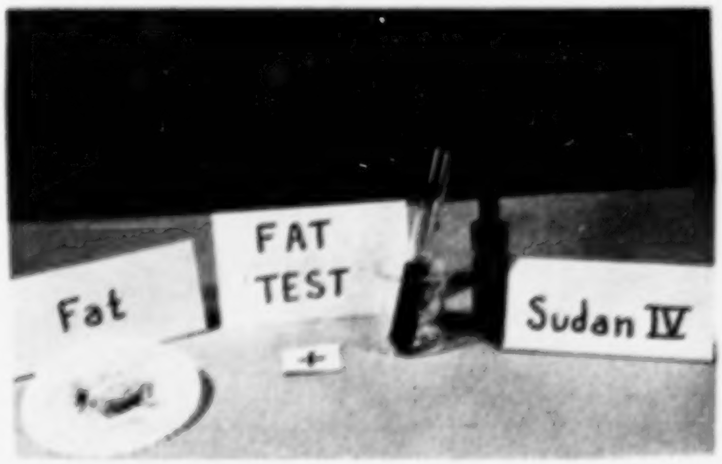
Slide D


Concentrated Nitic Acid
PROTEIN TEST
Bean Seed

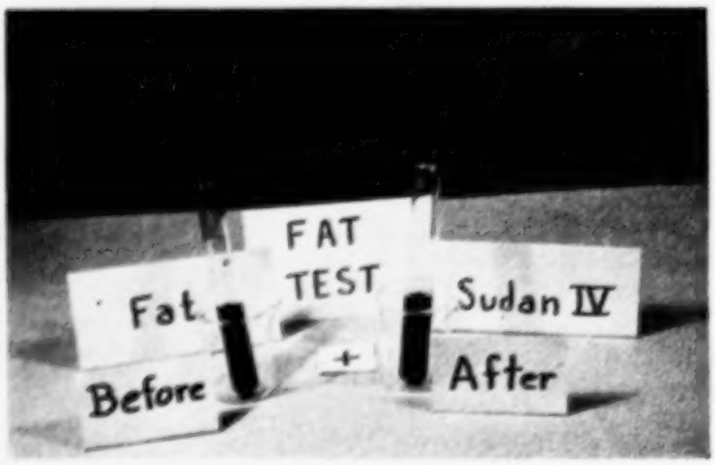
Slide E


PROTEIN TEST
Before
Bean in acid
After

Slide F


Fat
FAT TEST
+
Sudan IV

Slide G


Fat
Before
FAT TEST
+
Sudan IV
After

Slide H

Biology 1
Matter and Energy Unit

Name ____________________
Period _____

Enzyme, Fermentation, and ATP Labs

I. Enzymes

A. Procedure

1. Collect 2-4 ml of saliva in a small graduated cylinder. (Chewing on a bit of clean parafin or rubber band may help.) Add tap water a little at a time until you have a total of 10 ml of diluted saliva. This solution contains the enzyme to be studied.

2. Fill 3 test tubes with 5 ml of starch solution. Mark as tubes 1, 2, and 3. Place 1 ml of saliva mixture in tube 1, and let stand for 5 minutes. Place 1 ml of saliva mixture in tube 2 and let stand for 30 seconds only. Place no saliva in test tube 3.

3. Place 5 ml of Benedict's solution in each of the 3 test tubes and boil in a water bath for 3 minutes.

B. Data

Test Tube	Describe Results
1	
2	
3	

C. Discussion

1. What happened to the starch?

2. Why the difference in the results?

3. What is another way of testing this reaction with using Benedict's solution?

4. What is the purpose of test tube 3?

II. Fermentation

A. Procedure

1. Place 10 ml of grape juice into each of 2 test tubes and mark test tube 1 and 2.
2. Place a few grains of yeast in test tube 1.
3. Set up both tubes as demonstrated.

B. Data - Describe the changes that occur.

C. Discussion

1. How do you know that fermentation has occurred?
2. How could you test to see if fermentation had occurred?
3. What is the purpose of test tube 2?

III. ATP

A. Procedure

1. Get a piece of rabbit neck muscle from instructor.
2. Carefully measure the muscle to the nearest mm.
3. Place a drop of ATP on muscle.

B. Data - What happens to the rabbit muscle?

Have instructor check the lab sheet when completed.

ENZYMES IN LIVING MATERIALS

Background.

For nearly every chemical reaction in living organisms, enzymes are present which affect the rate at which the reaction occurs. In this demonstration, you will see evidence of an enzyme called catalase. This enzyme is found in most higher animals. You will have an opportunity to compare catalase with a substance not found in living organisms that affects the same reaction.

Hydrogen peroxide is a highly active chemical often used for bleaching or for cleansing minor wounds. It is also formed continually as a by-product of chemical reactions in living cells. It is poisonous, and if it were not immediately removed or broken down by the cells it would destroy them. In the presence of an enzyme, hydrogen peroxide is converted into two harmless substances, water and oxygen.

Materials.

Fresh 3% hydrogen peroxide solution
Small test tubes
Tweezers
Liver, fresh beef
Mortar & pestle
Fine sand
Manganese dioxide powder
Splint

Procedure.

(1) Pour hydrogen peroxide solution into each of two test tubes to a depth of about 2 cm. (less than 1 inch). Into one of the test tubes sprinkle a pinch of fine sand. Note the result, if any. Into the second test tube sprinkle the same amount of manganese dioxide powder. Note the result, if any.

(2) Pour hydrogen peroxide into a clean test tube to a depth of about 2 cm. Using your tweezers, select a small piece of liver and drop it into the test tube. Note the result.

(3) Take a piece of liver about the same size as the one you used before, and place it in a mortar along with a little fine sand. Grind the liver, and then transfer the ground material with a splint to a clean test tube containing hydrogen peroxide solution. Compare the result with the results observed for the whole piece of liver.

(4) Take a small piece of liver from the pan of hot water on the hot plate. This liver has been boiled for two minutes. Drop this liver into a test tube containing hydrogen peroxide. Note the result.

Record of Observations.

AFFECT ON HYDROGEN PEROXIDE OF:	NO EFFECT	SOME EFFECT	DEFINITE EFFECT
SAND			
MANGANESE DIOXIDE			
WHOLE LIVER			
GROUND LIVER			
BOILED LIVER			

Discussion:

(1) What effect does grinding the liver have upon the apparent catalase activity? How can this be explained?

(2) What effect does boiling the liver have upon the apparent catalase activity? How can this be explained?

(3) Compare the effects of manganese dioxide and catalase on hydrogen peroxide.

(4) How could you demonstrate that the gas given off by the action of catalase activity is oxygen? [Recall observations of first day.]

(5) Using the formula H_2O_2 for hydrogen peroxide, O_2 for oxygen gas, and H_2O for water, write a statement of the reaction in symbolic form.

Part V ATP*

The two examples given at the beginning of our discussion of enzymes showed that enzymes can affect chemical reactions in living organisms in the same way that heat energy affects chemical reactions in the laboratory. In these two examples, heat energy was used for two purposes: (1) to increase the frequency of effective collisions, and (2) to supply the difference between the energy content of the reactant molecules and the energy content of the product molecules. Heat energy was also evident as a product when the chemical bonds of sulfuric acid molecules were broken. [See observations of first day.] Enzymes used by the living organisms reduce the need for heat energy (high temperature) to increase the frequency of collisions.

Therefore, reactions which are proceeding so slowly they virtually are not occurring are accelerated by enzymes, and these reactions occur at ordinary temperatures. It was shown that, as enzyme molecules are the same after the reaction as before, no energy has been permanently lost from the enzyme.

There are two reasons why heat cannot be used by the living organism to do its chemical work. If a living organism were heated above a certain temperature (less than 100°C), a temperature that would be inadequate for the chemist's purpose, it would die because of denatured proteins, including its enzymes.

Secondly, heat is nonspecific in its effects; all reactions are affected at once. The life of the organism depends upon the performance of the proper reaction in the proper place at the proper time. If you were to push all of the keys on a typewriter many times, you would have done all of the work necessary to type a letter, but your energy would have brought $7*+Sb, not a letter.

Enzymes, while performing in the living organism some of the functions of heat energy used by a chemist, cannot account for the difference in energy contents of reactant and product molecules. Energy is needed for the living organism to manufacture new complex molecules such as fats and proteins and for life processes such as movement, reproduction, and removal of waste products. The energy used by the living organism is the chemical energy of the bonds of complex molecules, but the major form of energy to make these bonds and which is released from these bonds cannot be heat energy without destroying the organism.

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* Parts V, VI, and VII were presented under a system A_1 mode to all students in the self contained classroom.

The substitution of chemical energy for heat energy in the reactions of a living organism is a bit of magic which works for all reactions. The magic can be examined in one generalized example. In this example we will assign arbitrary energy contents to the molecules involved in order to clarify the nature of the trick.

Consider the reactions where simple, low-energy reactant molecules, B and C, form a complex, high-energy molecule, D, when energy is added. Another product, E, incidentally results from the process:

$$\text{REACTING MOLECULES:}\quad (\text{ENERGY}) + B + C \rightarrow D + E$$

$$\text{THEIR ENERGY CONTENTS:}\quad 1 + 2 + 2 \rightarrow 3 + 2$$

In a living organism the additional energy is transferred to one of the reacting molecules from some other energy-rich molecule, which may be represented as XR. If part of this molecule, R, combines with B, it transfers some of the energy from XR to B. Characteristically, an enzyme speeds up the reaction.

$$\text{REACTING MOLECULES:}\quad B + XR \xrightarrow{\text{ENZYME}} BR + X + \binom{\text{ENERGY}}{\text{WASTED}}$$

$$\text{THEIR ENERGIES:}\quad 2 + 6 \qquad\qquad 5 + 2 + 1$$

Then the now energy-rich BR can combine with the other reacting molecule, C. to form D and E:

$$\text{REACTING MOLECULES:}\quad BR + C \xrightarrow{\text{ENZYME}} D + E + R + \binom{\text{ENERGY}}{\text{WASTED}}$$

$$\text{THEIR ENERGIES:}\quad 5 + 2 \qquad\qquad 3 + 2 + 1 + 1$$

These two partial reactions show that an organism actually makes the complex product molecules by the following reaction:

$$\text{REACTING MOLECULES:}\quad B + C + XR \rightarrow D + E + X + R + \binom{\text{ENERGY}}{\text{WASTED}}$$

$$\text{THEIR ENERGIES:}\quad 2 + 2 + 6 \rightarrow 3 + 2 + 2 + 1 + 2$$

The magic is that both of the partial reactions release energy in spite of the fact that the product molecules, D and E, together contain more energy than the reactants B and C. Nevertheless, there has been no gain in total energy. The extra energy comes from XR, which had six energy units and was eventually split into X and R with a total of only three units. One of the units that it released went into the product D, and the other two were lost.

In this example XR was provided to the reactant molecules. However, the supply of XR would have to be replenished. We still must consider those reactions of living organisms where the energy of the chemical bonds of complex molecules is released without producing quantities of heat sufficient to destroy the organism. Let us continue with the same generalized example to see more of the magic of living organisms which handles both of these problems.

We can represent a reaction where the energy of complex molecules is released during the formation of smaller molecules by:

$$\begin{array}{ll} \text{REACTING MOLECULES:} & M \xrightarrow{\text{ENZYME}} O + P + \left(\begin{array}{c}\text{ENERGY}\\ \text{WASTED}\end{array}\right) + \left(\begin{array}{c}\text{ENERGY}\\ \text{RELEASED}\end{array}\right) \\ \text{THEIR ENERGIES:} & 7 \longrightarrow 2 + 1 + 1 + 3 \end{array}$$

In a living organism, the threeunits of energy released from M would not produce heat; these units are used to replenish the supply of XR in a reaction:

$$\begin{array}{ll} \text{REACTING MOLECULES:} & X + R + \text{ENERGY} \xrightarrow{\text{ENZYME}} XR \\ \text{THEIR ENERGIES:} & 2 + 1 + 3 \longrightarrow 6 \end{array}$$

The overall reaction would be:

$$\begin{array}{ll} \text{REACTING MOLECULES:} & M + X + R \longrightarrow O + P + XR + \left(\begin{array}{c}\text{ENERGY}\\ \text{WASTED}\end{array}\right) \\ \text{THEIR ENERGIES:} & 7 + 2 + 1 \longrightarrow 2 + 1 + 6 + 1 \end{array}$$

The bit of magic of our examples, which enables a living organism to substitute chemical energy for heat energy, has been represented by XR. The composition of XR is now well known and is nearly always the same in all reactions in plants and animals. It is a complex molecule named adenosine triphosphaste, or ATP for short.

Ignoring the details of the structure, we can let A stand for adenosine (a combination of a sugar and an amino acid) and P for phosphoric acid, so we can write the structure of ATP as follows:

$$A - P \sim Ⓟ \sim Ⓟ = ATP$$

The ATP molecule has a high chemical energy content which we can think of as largely concentrated in the two phosphate groups on the end and the bonds which attach them. This is indicated by the wavy bond symbol $\sim$Ⓟ, a bond which has six times the energy of the regular bond -P. When ATP gives up a high energy phosphate group, $\sim$Ⓟ, to combine with another molecule the remainder is adenosine diphosphate, or ADP for short. Its structure can be represented as:

$$A - P \sim Ⓟ = ADP$$

The most important advantage of these sequences of changes is that energy is transferred a little at a time. The energy, just enough to change -P to $\sim$Ⓟ, $\sim$Ⓟ back to -P, is small enough to be handled by a living organism. The energy necessary for the work and functioning of a living organism comes from the conversion of ATP molecules to ADP molecules. Energy released from complex molecules is "stored" as the chemical energy in the P bonds of ATP when ADP molecules are changed to ATP molecules.

Part VI Fermentation

The single most common source of chemical energy in plants and animals, the "M" of the previous reactions, is the simple sugar glucose. Although there are many chemical reactions which release the energy of glucose, we can use, as an example of such reactions, a group of reactions known as fermentation. Fermentation is the general name of reactions which release energy from organic molecules in the absence of oxygen and occurs in many protists, plants and animals.

Fermentation's products have been known since the time of the earliest man. Tribes of nomads must have learned that under certain conditions milk would change to cheese. Men also have been using fermentation to change fruit juices to alcoholic beverages. Work in the early 1800's showed that fermentation of glucose produces carbon dioxide and alcohol in a relationship shown as:

$$1\ \mathrm{C_6H_{12}O_6} \rightarrow 2\ \mathrm{C_2H_5OH} + 2\ \mathrm{CO_2}$$

1 molecule glucose	2 molecules ethyl alcohol	2 molecules carbon dioxide

When the French winemaking industry had serious trouble with wine that had spoiled, Louis Pasteur was called in to help. Pasteur learned that fermentation which produced wine was associated with living yeast cells. He found that certain bacteria were also capable of changing on fermentation, but that they produced vinegar instead of wine, containing alcohol. A later accident showed that the yeast cells themselves were not necessary for fermentation to take place; the cells produced many enzymes which fermented sugar to alcohol and carbon dioxide.

Fermentation takes place in twelve major steps with a separate enzyme for each step. Three of these steps change the glucose molecule such that its separation can be accomplished in nine more steps to form alcohol. Remembering that our magic molecule is ATP we can summarize these twelve steps as:

$$\mathrm{C_6H_{12}O_6} + 2\ \mathrm{ATP} \xrightarrow{\text{ENZYME}} \mathrm{C_6H_{12}O_6} \sim \textcircled{P} \sim \textcircled{P} + 2\ \mathrm{ADP}$$

$$\mathrm{C_6H_{12}O_6} \sim \textcircled{P} \sim \textcircled{P} \xrightarrow{\text{ENZYME}} 2\ \mathrm{C_2H_5OH} + 2\ \mathrm{CO_2} + 2\ \text{-P} + 4\ \mathrm{ATP} + \left(\begin{matrix}\text{ENERGY}\\ \text{WASTED}\end{matrix}\right)$$

$$2\ \mathrm{ADP} + 2\ \text{-P} + \text{ENERGY} \rightarrow 2\ \mathrm{ATP}$$

For each glucose molecule, *two* ATP molecules are required at the start of fermentation, and *four* ATP molecules are produced during fermentation from lower energy ADP's. Thus, for each glucose molecule there is a net gain of *two* ATP molecules and a corresponding gain in energy stored in the ~Ⓟ bonds of ATP. In addition, two molecules of carbon dioxide are produced. (You might be interested in the fact that for every 99 parts of ethyl alcohol yeast produces, it produces one part of fusel oil, a mixture of more complex alcohol molecules. The fusel oil is not only responsible for most of the flavor of liquor, but also for hangovers!)

Not all fermentations have alcohol as the main product, nor do they start with glucose. If the starting material is something other than glucose, then a few preliminary steps are required to change the materials into the glucose-phosphate complex. The steps in fermentation are the same until pyruvic acid, an intermediate product, is formed. While yeast enzymes convert pyruvic acid to alcohol and carbon dioxide, some bacteria possess enzymes which change pyruvic acid to acetic acid (vinegar) and carbon dioxide. (Acetic acid is a fatty acid.) These bacteria were discovered and later controlled by Louis Pasteur for the wine industry. The fermentation which occurs in man takes place in muscles which are being used extensively and rapidly. The end product here is lactic acid (also the acid of sour milk), the accumulation of which is responsible for the temporary tiring of the muscle.

Fermentation reactions are not the most effective or efficient way of releasing the energy of glucose molecules. The product molecules, alcohol, acetic acid, lactic acid, etc., still have large amounts of energy in their bonds. Alcohol is a fuel, both for lamps and for rockets. Every 180 grams of glucose has the energy of 686,000 calories. Other kinds of reactions obtain as much as 480,000 calories of energy of the 686,000, yielding 40 ~Ⓟ bonds or 40 ATP's. Fermentation reactions which result in only a net gain of two ~Ⓟ bonds, release only 5% as much energy from glucose.

Part VII Synthesis

Fermentation served as an example of the separation reactions as they occur in living organisms. Such separation reactions release the energy of complex molecules to the ATP-ADP cycle while forming simple molecules. This is how an organism obtains energy to perform its work. The other basic type of reaction of living organisms are synthesis reactions, where complex molecules such as carbohydrates, fats and proteins are made from simple molecules such as glucose, fatty acids and glycerol and amino acids. The properties of all synthetic processes of living organisms may be generalized as follows:

1. All synthetic steps are enzyme-controlled.

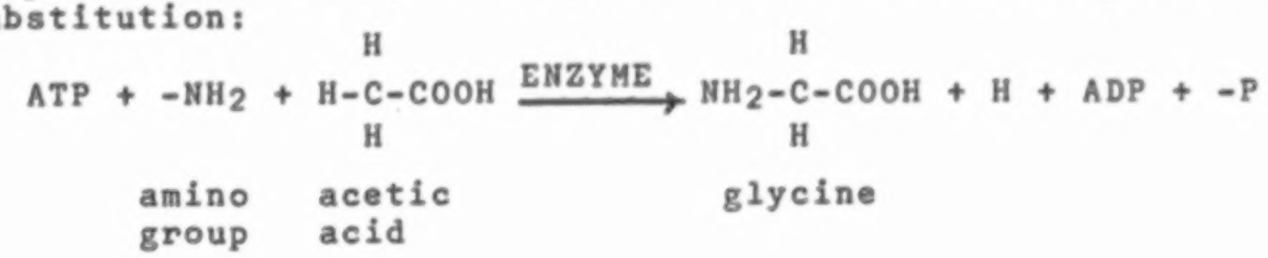
2. All syntheses consume energy, provided by ATP → ADP conversions.

3. All organisms tend to build the complex molecules from relatively few basic molecules.

4. All organisms tend to link molecules together by the removal of water from the combining molecules.

5. All syntheses obtain energy and/or materials from the separation of glucose molecules.

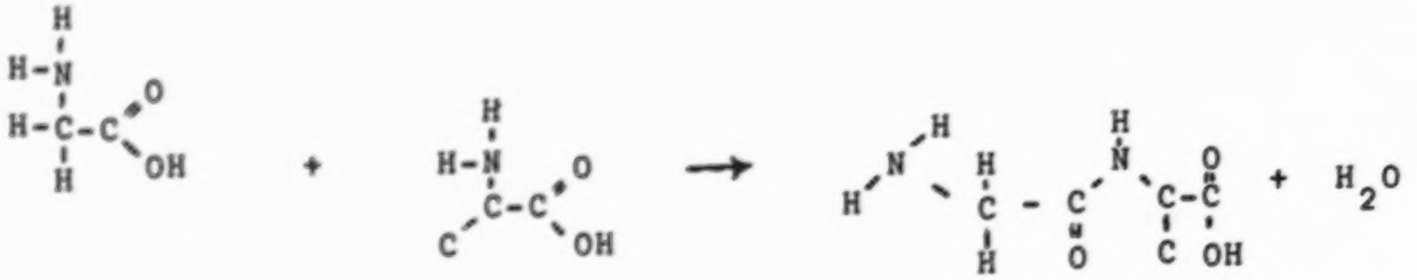
An examination of proteins' synthesis will serve as a model. Fatty acids are not only used in the synthesis of fats; they are also employed in the synthesis of proteins. First, they are transformed into amino acids. In this process which is enzyme controlled, one hydrogen atom in the fatty acid molecule is replaced by an amino group $-NH_2$. Glycine, the simplest amino acid, is obtained from acetic acid by such a substitution:



$$ATP + -NH_2 + H-\overset{H}{\underset{H}{C}}-COOH \xrightarrow{ENZYME} NH_2-\overset{H}{\underset{H}{C}}-COOH + H + ADP + -P$$

In plants the amino group is obtained from nitrates, $(-NO_3)$, compounds found in soil. Animals are not able to change nitrates to amino groups and thus are dependent on plants for their amino groups.

The next step in the synthesis consists basically of linking amino acids together into chains. A hydrogen from the amino group of one amino acid and the -OH atoms from the acidic group (-COOH) of another are removed to form water. This can be shown as:



Proteins are built up by the production of chains of enormous length and diversity in the sequence of the amino acids which compose them. Each time a link is made, an enzyme is used (different enzymes for different links), an ATP is changed to the lower energy ADP, and a water molecule is produced.

Syntheses and related transformations again illustrate the amazing unity and diversity of life. The same sorts of chemical reactions, even in some cases the identical reactions, go on in an amoeba, an alga, a man or a redwood. All synthesize proteins from the same materials: a few fairly simple amino acids.

All perform this synthesis in the same way, involving the loss of water, the formation of a long chain, and expenditure of energy from ATP sources. Yet each sort of organism makes proteins peculiar to that sort, and even each individual has a different combination of protein from every other individual. (The only exceptions occur when two or more individuals arise from a single source individual, such as the development of identical twins in humans.

All organisms perform many syntheses, but none can synthesize all needed substances from their elements. Humans require ascorbic acid (Vitamin C) in their diet as we cannot make this synthesis. Rats, although rather closely related to us (mammals) and generally similar biochemically, can synthesize ascorbic acids as can most other plants and animals.

Matter-Energy Unit

Study Questions on Fermentation and ATP

1. List two reasons why heat cannot be used by living organisms to do its chemical work.

2. List two uses of heat energy in a laboratory. Which of these functions is NOT performed by enzymes in the living organism?

3. How can the product molecules have more energy than the sum of the reactant molecules? Explain in terms of XR and two partial reactions; show where the extra energy came from.

4. How is the energy released from complex molecules used? Explain in terms of ADP and ATP.

5. What is the difference between the wavy bond, $\sim$P, and a regular bond, -P? Describe the structure of ADP and ATP in terms of the number of each kind of bond.

6. In terms of ATP, where does an organism obtain the energy to make up the difference between the product molecules' energies and the reactant molecules' energies?

7. If the ADP- ATP- ADP is compared to a reserve bank account, could you extend the comparison to the system of payments?

8. What compound is the single most common source of chemical energy in plants and animals? How many carbon atoms are in the compound?

9. Define fermentation. Are these synthesis or separation reactions? Will energy be a reactant or a product of such reactions?

10. Name two common products of fermentation reactions. How many carbon atoms are there in each of these products?

11. Cite evidence from your experiences that enzymes can work when the enzymes are not inside cells. [Consider experiences from the first day].

12. List all the products of a fermentation reaction, including the number of ~P bonds. Of those which contain carbon, how many carbon atoms are there in each molecule?

13. Why is fermentation considered an inefficient means of energy production?

14. Restate in your own words the five generalizations about synthesis reactions.

15. How are fatty acids changed into amino acids?

16. When two amino acids are linked together, where does the H_2O come from?

17. Schematically show the linking of a third amino acid to two linked amino acids.

18. Account for the great diversity of proteins possible in living organisms.

Matter-Energy Unit
Quiz II

DO NOT WRITE ON THIS SHEET: USE ANSWER SHEET

1. The complexity of molecules in living organisms is the result of

    a. their presence in living organisms.
    b. the large number of atoms involved.
    c. the arrangement of the atoms in space.
    d. their presence in living organisms and their arrangement in space.
    e. the large number of atoms involved and their arrangement in space.

2. The formula "$C_6H_{12}O_6$" is a

    a. molecular formula.
    b. structural formula.
    c. atomic formula.
    d. atom.

3. A structural formula

    a. is three dimensional.
    b. shows spatial arrangement of the atoms involved.
    c. separates important atoms from unimportant atoms.
    d. shows only the number and kind of atoms in a molecule.

4. Organic substances, in modern acientific terminology, are

    a. those found in living organisms.
    b. those that contain carbon.
    c. those found in non-living structures.
    d. those which are basic to other substances.

FOR QUESTIONS 5 - 15 USE ONE OR MORE OF THE FOLLOWING POSSIBLE ANSWERS AS APPROPRIATE:

- a. carbohydrate
- b. sugar
- c. fat
- d. starch
- e. protein

5. Contain carbon, hydrogen, and oxygen.

6. Contain nitrogen.

7. Contain hydrogen and oxygen in a ratio of two to one.

8. Are a source of energy for living organisms.

9. Are used as building materials.

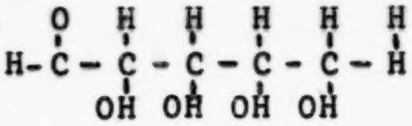
10. Are built up of linked components.

11. Are known for the size and complexity of their molecules.

12. $C_3H_5(C_{15}H_{31}COO)_3$

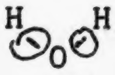
13. $CH_3CHOHC_2O_2HNH_2$

14.



$$\begin{array}{lcccccc} & O & H & H & H & H & H \\ & | & | & | & | & | & | \\ H- & C- & C- & C- & C- & C- & H \\ & & | & | & | & | & \\ & & OH & OH & OH & OH & \end{array}$$

15. $C_6H_{12}O_5$

16. In a structural formula such as , the circled lines represent

a. sticks between atoms.
b. punctuation to separate symbols.
c. forces which hold molecules together at reactive points of atoms.
d. none of the above.

17. The conversion of hydrogen peroxide to water and oxygen

a. does not occur at all except in the presence of manganese dioxide or catalase.
b. requires extra energy for the reaction to take place.
c. takes place very slowly except in the presence of manganese dioxide or catalase.
d. is not really vital to a cell.

18. The properties of enzymes do NOT include

a. specificity.
b. one molecule of enzyme must be present for each molecule or reactant.
c. large in size in comparison to reactant molecules.
d. their activity is affected by extremes of temperature.

19. The only statement which is true among the following is

a. Enzymes are composed of protein and vitamins.
b. Enzymes do not come into physical contact with either of the reactant molecules.
c. Enzymes can act at high or low temperatures, but act more rapidly at body temperatures.
d. Enzymes act only in separation reactions.

20. Based on the laboratory exercise which of the following would best represent synthesis of hydrogen peroxide?

a. $H_2O + O \rightarrow H_2O_2$
b. $E_1 + H_2O + O \rightarrow H_2O_2$
c. $E_1 + H_2O + O_2 \rightarrow H_2O_2$
d. $E_1 + 2H_2O + O_2 \rightarrow 2\ H_2O_2$
e. $H_2O + O_2 \rightarrow H_2O_3$

POST-TEST: MATTER/ENERGY PACKAGE

PLACE ALL ANSWERS ON THE ANSWER SHEET BY BLACKENING IN THE BEST OR MOST APPROPRIATE CHOICE. DO NOT WRITE ON THE EXAM.

1. An obvious example of kinetic energy would be

    a. the gas stored in a cylinder.
    b. a basketball placed at the top of a stairway.
    c. the movement of water in a stream.
    d. a bullet in a gun.

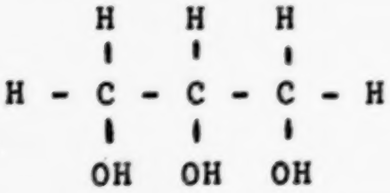
2. When a substance is heated, the distance between the molecules

    a. increases.
    b. decreases.
    c. neither increases nor decreases.
    d. both increases and decreases.

3. The molecules of a rock are ______ the molecules of water.

    a. closer together than
    b. farther apart than
    c. the same distance as
    d. moving faster than

4. The difference between $C_3H_5(OH)_3$ and

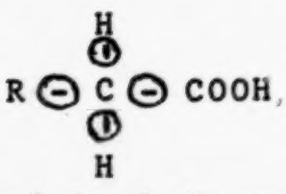


$$\begin{array}{ccccccccc} & & H & & H & & H & & \\ & & | & & | & & | & & \\ H & - & C & - & C & - & C & - & H \\ & & | & & | & & | & & \\ & & OH & & OH & & OH & & \end{array}$$

is ________.

    a. the second represents a three dimensional view of the molecule;
    b. the reader knows the H's are joined together.
    c. the relative position in space of the atoms in the molecule are shown as two dimensions in the second representation.
    d. they represent different molecules.

5. In a structural formula, such as



$$\begin{array}{ccccc} & & H & & \\ & & \textcircled{|} & & \\ R & \ominus & C & \ominus & COOH \\ & & \textcircled{|} & & \\ & & H & & \end{array}$$

The circled bars represent ____.

    a. sticks between the solid atoms.
    b. the energy associated with the function of reactive points.
    c. division between sections of the molecule.
    d. punctuation used with symbols for atoms and molecules.

6. A chemical reaction between ammonia gas and acetic acid forms glycine, a simple amino acid, and hydrogen gas.

$$E_1 + NH_4 + CH_3COOH \longrightarrow CNH_3COOH + H_2$$

In this reaction, ammonia (NH_4) is ______

a. synthesized.
b. separated.
c. neither.

Questions 7 - 8

Fats can be digested by adding water in the presence of an enzyme.

$$C_3H_5\ (C_{15}H_{31}COO)_3 + 3\ H_2O \xrightarrow{\text{enzyme}} \underset{\text{glycerol}}{C_3H_5(OH)_3} + 3\ \underset{\text{fatty acid}}{C_{15}H_{31}COOH} + E_1$$

7. In this reaction, fat is _____

a. synthesized.
b. separated.
c. neither.

8. In this reaction, glycerol is

a. synthesized.
b. separated.
c. neither.

9. Identify the possible products in the following reactions

$$\text{Molecule A + molecule B} + E_1 \longrightarrow \_\_\_\_\_$$

a. cannot be predicted.
b. molecule C + E_2 ($E_1 \neq E_2$)
c. molecule B + E_2
d. molecule A + E_1

10. Identify the possible reactants in this reaction.

$$\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \xrightarrow{\text{enzyme}} \text{molecule B} + E_1$$

a. molecule A
b. molecule B
c. molecule A + E_1
d. molecule A + B

Questions 11 - 12 are based on the following chemical equation,

$$C_6 H_{12} O_6 \longrightarrow 2\ CH_5OH + 2\ CO_2 + \text{heat}$$

11. The reactants are

    a. $C_6 H_{12} O_6$
    b. $C_6 H_{12} O_6$ and $2\ CH_5 OH$
    c. $2\ CO_2$ + heat
    d. $2\ CH_5OH$
    e. $2\ CO_2$

12. The most complex molecule (particle) would be

    a. CO_2
    b. $C_6 H_{12} O_6$
    c. CH_5OH

Questions 13 - 15 are based on the chemical equation below.

$$2\ H_2O + E_1 \longrightarrow 2\ H_2 + O_2$$

13. The reactants are

    a. $2\ H_2$
    b. $2\ H_2 + O_2$
    c. $2\ H_2O + E_1$
    d. $2\ H_2O + O_2$

14. The products are

    a. $2\ H_2$
    b. $2\ H_2 + O_3$
    c. $2\ H_2O$
    d. $2\ H_2O + O_2$

15. On which side of the arrow is there more stored energy.

    a. left.
    b. right.
    c. neither

Questions 16 - 18 refer to the following equation.

$$2\ H_2O \xrightarrow{\text{electricity}} 2\ H_2 + O_2$$

Key: A. 1 D. 4
B. 2 E. 5
C. 3 F. more than 5

16. How many different kinds of atoms are represented?

17. How many kinds of molecules are represented?

18. How many elements are represented?

19. Fats can be distinguished from carbohydrates chemically by

    a. the ratio of carbon in fats to oxygen in the carbohydrates.
    b. the one to one ratio of carbon in fats to carbon in the carbohydrates.
    c. the fact that carbohydrates have a two to one ratio of H to O while fats have a greater ratio.
    d. none of these.

20. Proteins can be distinguished from fats and carbohydrates by their

    a. amino group.
    b. acid group.
    c. their ratio of H to O of three to one.
    d. none of these.

21. Amino acids are to proteins as _____ are to fats.

    a. amines
    b. starches and sugars
    c. glycerol and fatty acid
    d. fatty acids

22. Amino acids are to proteins as _____ are to starches.

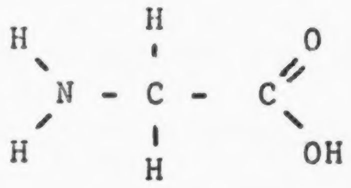
    a. amines
    b. starches
    c. glycerol and fatty acid
    d. fatty acids
    e. sugars

23. Dr. Sidney Fox, at the University of Florida, places a mixture of amino acid in a sealed container and heated it. At the end of twenty-four hours he found, by analysis, that he had his principle product and water.

    Dr. Fox's principle product was most likely.

    a. a carbohydrate.
    b. a fat.
    c. a protein.
    d. no way of predicting what product was formed.

24. The organic molecule represented by the structural formula below would be a



a. fat.
b. carbohydrate.
c. amino acid.
d. vitamin.
e. none of these.

25. The presence of the element nitrogen in an organic compound from a living organism indicates that the compound is a

a. fat.
b. carbohydrate.
c. protein.
d. vitamin.
e. information insufficient.

26. The organic compound best represented by the general formula CH_2O would be a

a. fat.
b. carbohydrate.
c. protein.
d. vitamin.
e. none of these.

27. The synthesis or separation of organic molecules in living things is dependent on the

a. presence of fats.
b. absence of protein.
c. presence of enzymes.
d. absence of carbohydrates

28. If the substance that broke down hydrogen peroxide were an enzyme

a. it could be recovered from the liver tissue after it caused the reaction.
b. it could not be recovered because it had been destroyed.
c. it could not be recovered because it was the active agent but could not be used again.
d. it could be recovered, but not in the same condition as before the reaction.

29. Enzymes involved in a chemical reaction

a. are used up during the reaction.
b. become decomposed during the reaction.
c. react more rapidly as the reaction progresses.
d. are not used up during the reaction.

Questions 30 - 32 refer to the following description and instructions.

Some test tubes were set up, each containing 1 gram (g) of fat. They were marked 1, 2, 3, 4, and 5. Various substances were added to the tubes after being dissolved in water. All test tubes were kept at 28°C (Water boiled at 100°C). For test tube 5 substance A was boiled and then allowed to cool before it was added to the fat.

Tube number	Contents of the Tube	Amount of Substance B after 24 hours
1	Fat + Substance A	.1 gram
2	Fat + Substances A & C	.5 gram
3	Fat + Water	.0 gram
4	Fat + Substance C	.0 gram
5	Fat + Substance A (boiled)	.0 gram

30. Substances A, B, and C are probably

a. carbohydrates
b. enzymes
c. fats
d. sugar

31. Which tube gives evidence that substance A is the active substance in the breakdown of fats to substance B?

a. Tube 1
b. Tube 2
c. Tube 3
d. Tube 4
e. Tube 5

32. Which tube provides evidence that Substance C alone is ineffective in the breakdown of fats?

a. Tube 1
b. Tube 2
c. Tube 3
d. Tube 4
e. Tube 5

33. Which is not a characteristic of an enzyme?

a. specificity
b. changes the rate of chemical reactions.
c. works best near body temperature.
d. is an organic molecule.
e. is the smallest particle of an element.

34. If the reaction below occurred in a living organism energy would probably be

$$C_3H_5(OH)_3 + 3C_{15}H_{31}COOH \xrightarrow{\text{enzyme}} C_3H_5(C_{15}H_{31}COO)_3 + 3H_2O$$

a. a reactant and then be stored.
b. a reactant and then released.
c. a product and stored.
d. a product and released.

35. Energy used mainly as a reactant in synthesis reactions in living organisms is provided by

a. kinetic motion of molecules.
b. heat.
c. ADP→ATP conversion.
d. ATP→ADP conversion.

36. All of the following are characteristics of synthesis reactions except

a. water is produced.
b. energy is gained in the form of ADP→ATP conversion.
c. large molecules are produced from small ones.
d. more atoms are found in the product than in any of the reactants.

37. The energy released from glucose is stored up in another molecule that can be used for various activities as "small change". The molecule in which this energy is stored is called

a. an enzyme
b. carbon dioxide.
c. ATP
d. ADP
e. alcohol

38. Fermentation occurs in the absence of

a. enzymes.
b. oxygen.
c. glucose.
d. ATP

39. Question 39 is based on the following:

A - Ⓟ~Ⓟ~Ⓟ

The wavy lines represent

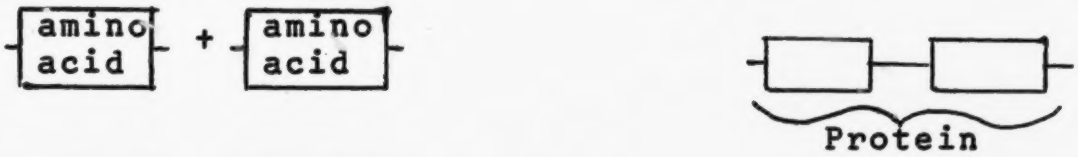
a. weak chemical bonds.
b. enzymes.
c. chains of glucose molecules.
d. high energy bonds.

40. Which of the following releases energy?

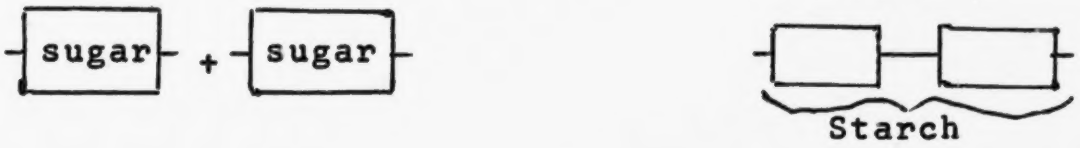
a. A -Ⓟ~Ⓟ~Ⓟ ⟶ A Ⓟ~Ⓟ + Ⓟ

b. Ⓟ + A - Ⓟ~Ⓟ ⟶ A —Ⓟ~Ⓟ~Ⓟ

c.


amino acid
+
amino acid
Protein

d.


sugar
+
sugar
Starch